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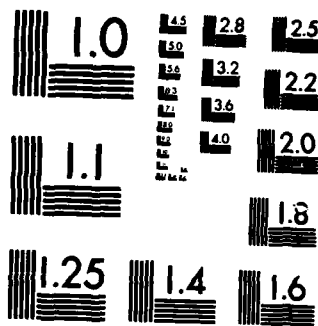
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NAVAL POSTGRADUATE SCHOOL

Monterey, California

AD-A150 998



THESIS

FORECASTING BEEF PRICES FOR
MILITARY SUBSISTENCE PROCUREMENT

by

Michael Jay Borza

June 1984

Thesis Advisor:

Alan W. McMasters

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**Forecasting Beef Prices
for Military
Subsistence Procurement**

by

**Michael J. Borza
Lieutenant, United States Navy
B.S., Pennsylvania State University, 1977**

Submitted in partial fulfillment of the
requirements for the degree of

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June 1984**

Author: Michael Jay Borza

Approved by: Alan W. McMaster
Thesis Advisor

John P. Z...
Second Reader

Will A. Dree
Chairman, Department of Administrative Sciences

Kenneth T. Marshall
Dean of Information and Policy Sciences

ABSTRACT

Defense Subsistence Region Pacific (DSRPAC) is responsible for the acquisition of food products (meat, fresh fruit and vegetables, etc.) for military personnel located west of the Rocky Mountains. In the author's review of current DSRPAC operations, it was observed that capitalizing on price movements was not a consideration during acquisition of beef products. Using time-series analysis, it was shown that significant seasonal price movements occur for selected stock items. Supplemental information and the initial stages of a forecasting model were developed to support replenishment decision making. It is recommended that price movements be incorporated within the acquisition strategy of DSRPAC. The criterion of supply effectiveness should always be foremost, consistent with DSRPAC's purpose, but need not be degraded by the introduction of cost efficiencies associated with an acquisition strategy that considers price movements.

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I. INTRODUCTION

A. BACKGROUND

In recent years, the need for improved management techniques in government has become increasingly clear. This need is due in part to the uncertainty and frequency of change in the economic and financial climate. The Federal Budget has continued to grow, forcing an internal re-evaluation of methods and policies consistent with efficient allocation of limited resources (\$). The need for improved management techniques has correlated with innovative information (computer) systems and the desire to apply technology to the planning and management of change. Information is a commodity to be valued.

Defense Subsistence Region Pacific (DSRPAC) is responsible for the acquisition of food products (meat, fresh fruit and vegetables, etc.) for military personnel located west of the Rocky Mountains. In the author's review of current DSRPAC operations, it was observed that capitalizing on price movements was not a consideration during acquisition of beef products. The incorporation of an acquisition strategy considering price movements has not been implemented due to DSRPAC's perception of being strictly a "service" organization. Considering the impact of stockouts on military personnel subsistence, it cannot be criticized for stressing supply effectiveness. However, are there price movements that could be incorporated within the acquisition strategy that would produce significant cost efficiencies?

This thesis recognizes the variety of products handled by DSRPAC but will concentrate only upon the acquisition of

frozen beef products held as stock items. Further refinement of the scope of this thesis eliminates reimbursable funds (commissary support) and concentrates upon appropriated funds (troop issue). Five specific products will be analyzed using historical time-series cost data: Ribeye Roll Steak (IMPS. 1112), Strip Loin Steak (IMPS. 1180B), Top Sirloin Steak (IMPS. 1184A), Top (Inside) Round (IMPS. 168), and Chuck Roll (IMPS. 116). These products were selected on the basis of the large volume purchased during the course of the year and/or a high unit value (price per pound). Potentially, this represents a substantial area for cost savings.

B. PURPOSE

The objectives of this thesis are:

- (1) Confirm existence of price movements.
- (2) Seek knowledge that could supplement DSRPAC's decision making for replenishment of inventory.
- (3) Develop a forecasting model that would predict price movements with a reasonable degree of accuracy and could easily be integrated within the current organizational structure of DSRPAC.

C. PREVIEW

Any recommendation for change must be based on a sound understanding of present operations. An overview of the major elements of the present operations of the meat supply system at DSRPAC is provided in Chapter II. Chapter III describes data procurement and lays the foundation for the development of a forecasting model that would predict price movements with a reasonable degree of accuracy. Chapter IV provides an in-depth cost analysis of the selected items and assesses the reliability and accuracy of the forecasting

models proposed. Chapter V summarizes the conclusions and recommendations resulting from this thesis.

II. DESCRIPTION OF OPERATIONS

A. INTRODUCTION

DSRPAC has as its parent command the Defense Personnel Support Center (DPSC) which is a branch of the Defense Logistics Agency (DLA). DSRPAC is responsible for the acquisition of food products (meat, fresh fruit and vegetables, etc.) for military personnel located west of the Rocky Mountains.

Congress annually appropriates funds for military personnel subsistence via military personnel expense appropriations to the various commands, e.g. sailors on ships or troops located on bases. It is with this funding that commands can submit requisitions to DSRPAC for the purpose of acquiring food products. If the appropriated funds were the sole source of funds used for acquisition, DSRPAC would only be acting as a purchasing agent for the various commands. To augment this arrangement, DSRPAC has a corpus of funding which allows greater management flexibility. Instead of only purchasing for commands upon demand, DSRPAC can maintain an inventory of products in anticipation of demand.

An overview of the major elements of the meat supply system at DSRPAC is shown in Figure 2.1. Attention will be given to three key departments within DSRPAC: Customer Service, Inventory Management Branch (IMB), and Meat Procurement. These departments combined are responsible for providing subsistence support for military personnel. The first two departments are part of Supply Operations. Supply Operations' primary objective is to maintain inventory levels capable of meeting demand requirements.

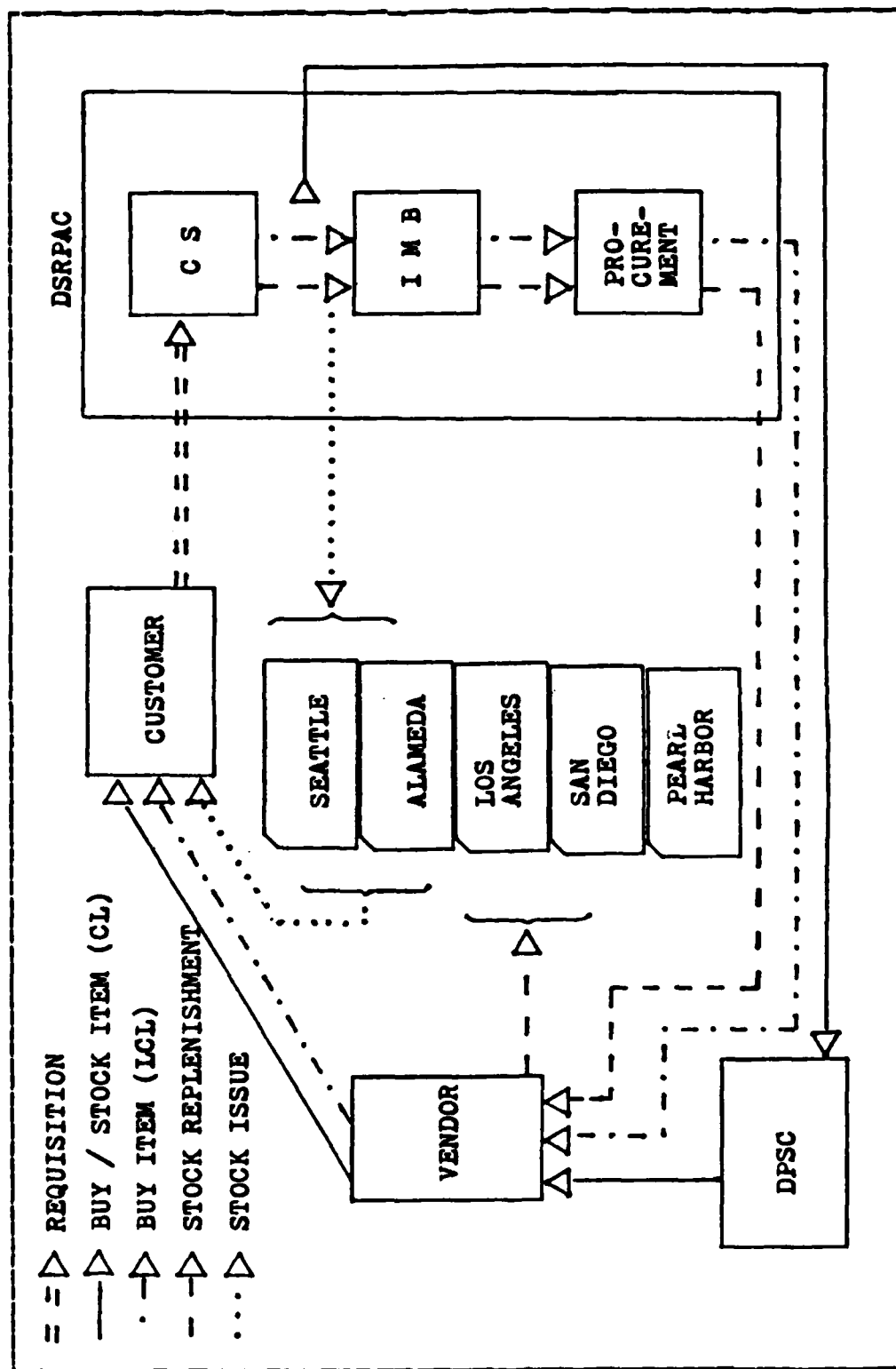


Figure 2.1 Schematic of DSRPAC Operations.

The latter department, Meat Procurement, is part of the Purchasing Division. The Purchasing Division's primary objective is to obtain quality products from responsible suppliers at a fair and reasonable price.

Common to all three departments is a computerized network system called the Perishable Subsistence Automatic Supply System (PSASS). Reports are generated by PSASS which aid the departments with decision making. Further explanation of PSASS will occur latter in the chapter. Customer Service, IMB, and Meat Procurement will be described in detail to develop an appreciation of current operations. Figure 2.1 is a helpful reference for this discussion.

B. CUSTOMER SERVICE

Customer Service is the interface between customers and DSRPAC. Requisitions are processed and entered into PSASS. Customer Service works closely with each command (customer) and acts as the information center with regard to the status of requisitions.

To allow for administrative and procurement lead time, requisitions submitted by customers must reflect required delivery dates (RDD) of not earlier than the following:

- (1) If the command is located in the Continental United States (CONUS), requisitions must be submitted by the twenty-fifth (25th) of the month if delivery is desired in the second successive month [Ref. 1]. For example, if the requisition was submitted between March 26th and April 25th, the "window" for delivery of goods would be between June 1st and June 30th. This represents a minimum of 35 days lead time for CONUS units. If the requisition was submitted after April 25th and prior to May 26th, the next possible "window" would be the month

of July. Each command has pre-established delivery schedules which allows for improved logistics coordination.

- (2) If a ship is arriving in port, the earliest date it can expect delivery is 10 working days after a requisition is submitted. However, it is possible to shorten lead time if necessary. Often, ship movements are a function of world events, and flexible or hurried deliveries may be required.
- (3) Overseas commands must submit requisitions reflecting delivery schedules of 85 to 90 days in the future [Ref. 2]. Customer Service estimates that 30 days of the required lead time of 85 to 90 days is for transportation overseas.

1. PSASS

Customer Service enters the requisitions into the computer network system on a daily basis. Two concurrent decision criteria are programmed within PSASS to initiate action at this point:

- (1) Is the requisition for a buy item (reimbursable funds/commissary support) or a stock item (appropriated funds/troop issue)?
- (2) Is the quantity requested a carload lot (CL) (total weight greater than or equal to 38,000 pounds) or less than carload lot (LCL)?

If the quantity requested is a carload lot, whether a buy item or stock item, the computer notifies DPSC in Philadelphia, Pennsylvania to initiate national solicitation of competitive bids for that beef product from vendors. Terms of the contract once awarded require direct vendor delivery (DVD) to the customer. Carload stock items are handled in this manner to avoid storage and handling costs associated with the cold storage facilities.

If the quantity requested is less than a carload lot and is a stock item, PSASS reviews the asset files of the cold storage facilities and initiates delivery from current on-hand supplies if possible. If the quantity requested is a buy item, the computer notifies IMB and triggers DSRPAC Procurement to solicit bids from vendors for direct vendor delivery to the customer.

Prior to the discussion of IMB, it is necessary to introduce three primary reports generated by PSASS and used by IMB:

- (1) Daily Inventory Status Report (DISR)
 - (2) Perishable Subsistence Automatic Supply System (PSASS)
(This is the same name used to refer to the entire network system.)
 - (3) Perishable Subsistence Supply Control Study (PSSCS)
- These reports enhance IMB's ability to monitor and control inventory levels.

C. INVENTORY MANAGEMENT BRANCH

The inventory managers in the Inventory Management Branch control the stock levels within the cold storage facilities. They monitor the inventory levels and make replenishment decisions to restock depleted supplies. Each inventory manager is responsible for specific stock items which may be stocked in any of the five area warehouse locations: Seattle, Alameda, Los Angeles, San Diego, and Pearl Harbor. (See Figure 2.1)

As previously noted, three reports are generated for use by IMB: the DISR, PSASS, and PSSCS. The DISR provides a daily inventory status of each item on hand segmented by warehouse. It is important for each inventory manager to be able to establish a current tabulation of inventory for comparison with the reorder point. If the on-hand quantity

drops below the reorder point, the inventory manager will issue a replenishment request.

The PSASS provides a daily summary of requisitions received for specific items. This report is segmented by products relevant to individual inventory managers. It is from this daily report that the managers can update the FSCCS, a monthly report, which projects actual and forecasted demand. The manager can also recompute demand projections to determine a reorder point and order quantity based on a combination of the PSASS and PSSCS.

The FSCCS provides two additional pieces of information necessary for inventory control: lead time¹ for product acquisition and average monthly demand (AMD). The AMD is based on historical demand patterns and is used as a forecast of future demand. The AMD provides the inventory manager with a tool to help offset uncertainty about future demand. Because unexpected demand can deplete inventory levels rapidly and the required lead time for administrative and procurement procedures is quite lengthy, the inventory manager tries to anticipate demand well before the actual requisitions are "in house".

An IMB manager's performance is measured on the basis of two criteria: supply effectiveness and inventory turnover rate. Quantitative targets consist of a 95% supply effectiveness (less than 5% not in stock (NIS)) and a turnover rate greater than or equal to 0.6. Thus, an impetus has been provided to not over or under stock.

The inventory turnover is calculated as follows:

$$ITR = CMS / ((PMICE + CMICB) / 2), \quad (\text{eqn 2.1})$$

¹For those products analyzed in this thesis, the average lead time was approximately 45 days. Three products had a lead time of 42 days and two products had a lead time of 49 days.

where,

ITR = inventory turnover rate;

CMS = current month sales;

PMICB = prior month inventory closing balance;

CMICB = current month inventory closing balance.

IMB would like to remain within an upper boundary of stock on hand of 45 days. The 45 days consist of 30 days (AMD) and 15 days of safety stock. If an overstockage condition exists, one means of reducing the level of stock is to communicate with Customer Service of the need to "push" the overstocked item. Customer Service may be able to find a command who desires the item.

1. PSASS

The PSCCS is worthy of additional comment. Besides providing important information such as AMD, lead time, etc., it also contains information such as shelf life of the product,² minimum procurement quantity, and demand history of the previous 6 months. Each piece of information assists the IMB manager with inventory control.

Finally, the buy file list (BFL), a product of the inventory manager's acquisition decision and final report generated by PSASS, serves as the vehicle of communication between IMB and Meat Procurement.

D. MEAT PROCUREMENT

The Meat Procurement Department is part of the Purchasing Division of DSRPAC. Once the decision has been made to purchase frozen beef for replenishment of stock, it is the responsibility of meat procurement to actually solicit bids. Notification from IMB to Meat Procurement for

²The products analyzed in this thesis had a shelf life of 10 months.

replenishment is accomplished by the BFL. The report contains nomenclature, quantity and requested RDD.

Bid solicitations are of two types, restricted (open to small business only, less than 500 personnel employed) or unrestricted (open to large or small businesses). In either case, the vendors consist of wholesalers or beef processor companies.

Bid solicitations are mailed to the various vendors. Each vendor must have previously established his quality standards of operations with DIA in order to be eligible for inclusion on the mailing list. Contained within the solicitation is the closing date after which no further bids will be accepted. Closing dates usually are 10 days after the mailing date. Each vendor may respond with a bid by letter, telegram, or teletype. Each bid represents a firm, fixed price offer from the vendor. Firm fixed price contracts for frozen beef are required by the Federal Acquisition Regulation (FAR), Vol.1 [Ref. 3].

Once the closing date has occurred, the contracting officer in procurement must respond to each bid within 24 hours. Selection of one vendor's bid over another's is determined by the lowest offer. However, this is not the final criterion for awarding a contract. The contracting officer must determine whether the lowest offer is also fair and reasonable. He or she may determine fair and reasonableness based on either:

- (1) adequate competition
- (2) published catalog or market price
- (3) recent competitive procurement of a similar item

Adequate competition is a function of the number of respondents. The published catalog or market price is provided by three publications which are relied upon to determine the current market price:

- (1) The National Provisioner Daily Market Service (commonly referred to as "The Yellow Sheet") [Ref. 4]
- (2) The Meat Sheet (commonly referred to as "the Pink Sheet") [Ref. 5]
- (3) The Meat Price Report, (Hotel, Restaurant, Institution) [Ref. 6]

Each daily publication contains various beef products and current market price quotations stated in price per pound. The price quotations in the first two publications represent current national average prices paid by wholesalers to processors. The third publication represents prices paid to wholesalers by commercial feeders.

Recent competitive procurement of a similar item is the third basis for determining "fair and reasonable." The Procurement Department maintains a purchase order register which contains past procurement history.

If the Procurement Department determines that all the bids received for a particular solicitation are not fair and reasonable, resolicitation via the phone would occur to those vendors who had initially offered a bid. Usually, a second solicitation provides the desired results and awarding of a contract.

Average delivery of the beef products into cold storage occurs 25 to 35 days after the firm fixed price is accepted. During this time span, the vendor is busy "producing" the product and undergoing an inspection of the meat by the United States Department of Agriculture (USDA). To prevent a vendor from unloading old product to the government, frozen products which have been in the vendor's storage for more than 30 days after initial acceptance of the bid will not be accepted into the government's cold storage facilities [Ref. 7].

E. CONCLUSION

In reviewing current operations of DSRPAC, it is observed that capitalizing on price movements is not a consideration of either the inventory branch managers in IMB or contracting officers in Procurement. The inventory manager's stock replenishment decision is a function of actual and forecasted demand. The contracting officers in Procurement, although they use price movements to determine "fair and reasonableness", are executing a previously made decision.

F. SUMMARY

The primary purpose of this chapter has been to describe current operations of DSRPAC. Figure 2.1 provided an overview of the major elements of the meat supply system. Three key departments within DSRPAC are: Customer Service, Inventory Management Branch (IMB), and Meat Procurement. These departments combined are responsible for providing subsistence support for military personnel.

III. DATA DESCRIPTION AND MODEL DEVELOPMENT

A. INTRODUCTION

This chapter has four objectives: to introduce the stock items to be analyzed, to describe data procurement, to confirm the existence of price movements within products stocked by DSRPAC, and to lay the foundation for the development of a forecasting model that can predict price movements with a reasonable degree of accuracy to supplement IMB decision making. Any forecasting model that is devised for implementation should be as economical as it is consistent with the technical skills of IMB managers and should provide proper support for accomplishing DSRPAC's purpose.

B. STOCK ITEMS AND DATA PROCUREMENT

Five beef products were selected from the publication, DPSC Technical Data Sheet for Chilled and Frozen Meat, [Ref. 7] for price movement analysis. All products were boneless and considered frozen boxed beef. They are listed below first by common name, then by institutional meat purchase specifications (IMPS), and finally by national stock number (NSN).

- (1) Ribeye Roll Steak, IMPS. 1112, NSN 8905-01-034-7548
- (2) Strip Loin Steak, IMPS. 1180B, NSN 8905-01-034-7547
- (3) Top Sirloin Steak, IMPS. 1184A, NSN 8905-01-034-7549
- (4) Top Round (Oven Roast), IMPS. 168, NSN 8905-00-133-5886
- (5) Chuck Roll (Pot Roast), IMPS. 116A, NSN 8905-00-133-5887

These products were selected on the basis of the large volume purchased during the course of the year and/or a high unit value (price per pound). According to the April 1984 PSSCS studies, the average yearly demand for each of the five products was:

- (1) Ribeye Roll--225,000 pounds--unit value of (\$4.57)
- (2) Strip Loin--1,250,000 pounds--unit value of (\$4.08)
- (3) Top Sirloin--342,000 pounds--unit value of (\$3.46)
- (4) Top Round--3,675,000 pounds--unit value of (\$2.06)
- (5) Chuck Roll--3,166,000 pounds--unit value of (\$1.65)

It appears that the only other beef product, not included in this study, that had a larger volume was ground beef. This product was not included in the study because of the lack of available data.

Two potential sources of cost data for this thesis were that reflected in the daily market publications and that from DSRFAC's past purchase order register. The latter was ruled out due to the infrequency of the data and resulting inability to project a continuous price picture for a reasonable time-series analysis. The former, based on the daily market publications, would allow construction of a time series. Unfortunately, these data were not readily available. In particular, only a few copies of the three primary market publications used by Meat Procurement to determine "fair and reasonableness" were available since only approximately one month of past publications is kept in Meat Procurement at any one time. Time and financial constraints precluded the acquiring of data directly from the publishers.

Fortunately, a local external data source was available; a wholesaler of beef products located in Central California. Four years of weekly data were available from 27 February 1980 to 15 February 1984. Each weekly quote was the result of a Wednesday transaction (LCL) and provided a constant time interval between observations. Unfortunately, this local source did not have data for three of the stock items. However, surrogate beef products were available to provide the needed information. Cost data was directly available for Top (Inside) Round (IMPS.168) and Chuck Roll

(IMPS.116A). Ribeye Roll Steak (IMPS.1112), Strip Loin Steak (IMPS.1180B), and Top Sirloin Steak (IMPS.1184A) represent further "processing" of Ribeye Roll (IMPS.112A), Strip Loin (IMPS.180), and Top Sirloin (IMPS.184) respectively [Ref. 8]. Theoretically, since each of these latter or surrogate products is the "basis" from which further processing takes place, any cost difference between the surrogate and actual stock item should be reflected in consistently parallel prices. It also follows that the stock items would be higher in cost than the surrogates. From a limited sample, the average price differential between the stock items and the surrogates used for Ribeye Roll, Strip Loin, and Top Sirloin was 39%, 44%, and 57%, respectively.

A legitimate concern at this point is whether the cost data obtained from the wholesaler in Central California is representative of vendors nationwide as reflected in the market publications or unique to that particular wholesaler. Without supporting evidence that the cost data are universally representative, the remainder of the analysis would be seriously flawed. Comparison of the cost data with data contained within Meat Price Relationships [Ref. 9] (summary of market publication quotations of selected products) proved that although the local wholesaler's cost data were consistently higher than the national average contained in reference 9, the plotting of the data exhibited remarkably similar seasonal trends for each of the five beef products.³

Two more questions should be considered regarding data validity: Are four years of cost data sufficient historical observations for a time series forecasting methodology?

³The reference, Meat Price Relationships, was not discovered until after the analysis based upon the wholesaler's cost data was initiated. Because the plotted curves were very similar, continuation of the use of the wholesaler's cost data was deemed appropriate.

Should any outlier adjustments of the data be made? The latter question will be addressed individually by product as necessary in Chapter IV. In response to the former question, increasing the number of years of data will generally increase the accuracy of forecasts but not necessarily in direct proportion to the amount of data. In addition, if the annual pattern changes rapidly over time, using a longer time span may in fact give less accurate results than using only the most recently available data [Ref. 10 : p.555]. Because the four years of cost data obtained from the wholesaler represented more recent data than that of Meat Price Relationships [Ref. 9] and roughly fulfilled the minimum data requirements proposed in Forecasting, Methods and Applications [Ref. 10 : p.556], the data was considered sufficiently valid to be useful for forecasting price fluctuations.

C. COMPARISON AND SELECTION OF FORECASTING METHODS

What forecasting model would be helpful to IMB managers that could predict price movements with a reasonable degree of accuracy? This section attempts to answer that question by analyzing two models. This analysis is based on usual criteria for evaluating such models. Five criteria are listed in Forecasting, Methods and Applications [Ref. 10 : pp.761-762]: accuracy, pattern of the data, time horizon effects, development and operating costs, and ease of application. Review of these criteria is important because of the interrelationships among them and the need to select that forecasting method that best meets all of the dimensions of a given situation.

In the majority of practical forecasting situations, accuracy is treated as the overriding criterion for selecting a forecasting method. Accuracy is the ability of

a forecasting model to predict patterns within the data. One method that measures the relative suitability of forecasting methods is the Mean Absolute Percentage Error (MAPE). The MAPE is calculated as follows. First, the absolute percentage error per observation is calculated using equation 3.1.

$$APE = ((|X - F|) / X) * 100, \quad (\text{eqn 3.1})$$

where,

APE = absolute percentage error;

X = observation (datum);

F = forecast.

The sum of each result is then averaged to give the mean absolute percentage error. The MAPE for each forecasting technique has been recorded in the tables provided in the appendices. [Ref. 10 : pp.43-47]

A data series can be described as consisting of two elements, the underlying pattern and randomness. The objective of forecasting is to distinguish between those two elements using the forecasting method that can most appropriately do so. Time-series analysis suggests that the pattern itself can be thought of as consisting of subpatterns or components. The three components most frequently used in describing elements of the pattern are trend, seasonality, and cycle. The pattern of the data is important in selecting a forecasting method because certain models can cope with only certain kinds of data patterns. There are, of course, elaborate models that can handle a very wide range of patterns, but these are usually more expensive to use and more difficult to apply; thus a trade-off is required in using them. [Ref. 10 : pp.776-777]

Time horizon refers to the period of time into the future for which forecasts are required. The time horizon

criterion for evaluating forecasting methods is closely related to the pattern criterion. One of the reasons the time horizon is particularly important in selecting a forecasting method is that the relative importance of different subpatterns changes as the time horizon changes. Furthermore, it is important to understand that as the time horizon of forecasting increases, the chances of a change in established patterns or relationships increase also (greater uncertainty). [Ref. 10 : pp.778-779]

The costs of forecasting depend very much on the model itself and its inherent complexity as well as on its data requirements and the number of items to be forecast. There are four main elements of cost in using a forecast model: development costs, data storage costs, maintenance costs, and the costs of repeated applications. [Ref. 10 : pp.782-785]

There are several factors that can be summarized under the criterion of ease of application. These include such things as the basic complexity of the model, its timeliness in providing forecasts when they are needed, the level of expertise required, and the conceptual appeal that the model has to the ultimate user. All of these elements are important, since in the end, they determine whether or not the forecasts will have an impact on management action. The ultimate user must understand the conceptual basis of the model and feel comfortable that it represents a "correct" approach. [Ref. 10 : pp.785-787]

In the interest of gaining acceptance by DSRPAC of any proposed forecasting technique, accuracy, although extremely important, must be weighed concurrently with the other four criteria. Acceptance and implementation by DSRPAC management of a forecasting method to capitalize upon price movements will require a methodology that has low cost, is intuitively appealing, provides "reasonable" accuracy, has

short term extrapolation capability, and can be developed from a data base consisting of current sources of information (market publications).

A matrix of the five criteria versus forecasting techniques has been aggregated for comparison and selection of forecasting methods in The Beginning Forecaster [Ref. 11 : p.23]. Based upon the criteria desired for DSRPAC, the matrix suggests two forecasting techniques: the Moving Average and Decomposition Methods. These will therefore be utilized in the development of a forecasting technique for use by DSRPAC.

D. FORECAST METHOD 1--(FOUR WEEK MOVING AVERAGE)

The Four Week Moving Average Method is the simplest technique. The algorithm is as follows: Sum the most recent four weeks of cost data and divide by four. The derived cost figure is the following week's forecast. The term "moving average" is used to describe this procedure because as each new observation becomes available, a new average can be computed by dropping the oldest observation and including the newest one. This method has the advantage of not requiring the use of a computer. Other major advantages of this method are the low cost, ease with which it can be applied, and the speed with which it can be adopted. These characteristics make it particularly attractive when a large number of different items are to be forecasted.

E. FORECAST METHOD 2--(DECOMPOSITION METHOD)

The equation used in Forecast Method 2 is:

$$\text{Expected future cost} = (\text{TC} * (\text{SIFD} / \text{SITD})), \quad (\text{eqn 3.2})$$

where,

TC = today's cost;

SIFD = seasonal index of future date;

SITD = seasonal index of today's date.

Forecast Method 2 is not in itself a classical decomposition method but rather the user of one specific product, seasonal indices, from the classical decomposition method. Decomposition methods usually try to identify three separate components of the basic underlying pattern that tend to characterize time series. These are the trend, the cycle, and the seasonal factors. The trend represents the long-run behavior of the data, and can be increasing, decreasing, or unchanged. The cyclical factor represents the ups and downs of the economy. The seasonal factor relates to periodic fluctuations of constant length and for our purposes will be assumed to be a function of the week of the year and that week's demand.

Appendices F and G contain computer programs written in FORTRAN that were developed and used in this analysis. The program within Appendix F calculates seasonal indices via the decomposition method. The output (seasonal indices) was used as input data to the program in Appendix G. The specific classical decomposition method utilized in the computer program in Appendix F is called the ratio-to-moving average method.

The ratio-to-moving average method assumes that the data can be described by the following equation:

$$\text{data} = (\text{T} * \text{C} * \text{S} * \text{I}), \quad (\text{eqn 3.3})$$

where,

T = trend component;

C = cyclical component;

S = seasonal component;

I = irregular component.

This method systematically separates the trend, cyclical, and irregular components from the original data. The systematic separation of the components of the data is accomplished as follows. Briefly, seasonal and irregular components are isolated from the data using a 52-week centered moving average. By dividing the original data ($T \cdot C \cdot S \cdot I$) by ($T \cdot C$), the ($S \cdot I$) component is reintroduced. The ($S \cdot I$'s) are called specific seasonals. There is one specific seasonal for each week of the series. To eliminate the irregular component (I) from the specific seasonals ($S \cdot I$), an average of all the specific seasonals for week 1 is computed using either the median or modified mean.* Then an average of all the specific seasonals for week 2 is determined, and so on until completion of 52 weeks. The 52 numbers which result are called the typical seasonal indices. The remaining pattern, seasonal component, was used in Forecast Method 2. [Ref. 12] For purposes of this study, only the first 156 observations (3 years of data) were used to develop the seasonal indices. The remaining year of data was the "test data" from which the accuracy of the forecast could be evaluated. This leads to one very important technical point in developing a forecast: the system must be tested against data which were not used to develop it [Ref. 13 : p.188]. One final note; the program in Appendix F was designed specifically to analyze the sequence of cost data as presented by the wholesaler from

*Because only 2 observations of specific seasonal indices would be generated per each week with 3 years of data prior to elimination of any irregular component, both specific seasonals were used to find the average or "typical seasonal index." (No observation was deemed inappropriate due to the lack of observations. Normally it is at this point that an outlier would be discovered and discarded.) (4 years of data would create 3 observations per each week, etc.)

February 1980 to February 1984. A slight modification would be necessary in order to make the program generic (able to handle greater than 3 years of data or a sequence from January to January).

F. SUMMARY

Chapter III described data procurement for five stock items and laid the foundation for the development of a forecasting model that would predict price movements with a reasonable degree of accuracy. Two forecasting models, Four Week Moving Average and the Decomposition Method, fit the criteria relevant to DSRPAC and were selected for further study.

IV. PRODUCT COST ANALYSIS

A. INTRODUCTION

The objectives of this chapter are to thoroughly analyze the cost data of each product, to assess the reliability and accuracy of the forecasting models proposed, and to simultaneously seek knowledge that could supplement IMB's inventory decision process.

It is helpful to develop an orientation of the various beef cuts of the steer. Figure 4.1 lists the primal cuts: Chuck, Rib, Loin, and Round, along with the subprimal cuts from each primal. The order is from front to rear of the

<u>Beef Cuts</u>	
Chuck__	Shoulder Clod
	Chuck Roll
Rib____	Ribeye Roll
Loin____	Strip Loin
	Top Sirloin
	Tenderloin
Round__	Knuckle
	Top Round
	Gooseneck

Figure 4.1 Beef Primal and Subprimal Cuts.

steer. Within the industry, Rib and Loin primals are referred to as the middle meat (also called summer meat). It is believed that the demand for these primals during the

summer increases significantly due to warm weather and the barbecue season. It is from this section of the steer that steaks originate. Based on this knowledge, the price should show significant increases during the summer months. Chuck and Round primals are referred to as end meat. Chuck is believed in the industry to follow the inverse of the summer meat and is referred to as winter meat. The price would be higher during the winter months (Chuck is made into roasts) and would experience a low point during the summer months when demand prefers middle meat. No such industry generalizations about demand and price movements have been made for the Round Primal.

B. RIBEYE ROLL (IMPS. 112A)

Appendix A contains the data presentation for the discussion that follows. For this product and the remaining ones, the following format will prevail. Table I is a presentation of the cost data from the wholesaler in Central California. Table II is a summary of the data analysis. Included are the forecasts for Method 1 and Method 2 along with their respective MAPE's. Column three is the row average of Table I. Column four is a listing of the seasonal indices calculated via the computer program in Appendix F. Figure A.1 is simply a plot of all 4 years of cost data. Figure A.2 is a row average of Table I with an X axis oriented from week 1 to week 52. Figure A.3 represents the seasonal indices calculated using the ratio-to-moving average method contained within the computer program in Appendix F. Once again the X axis is from week 1 to week 52. Figure A.4 is a plot of the comparison of forecast methods versus the last year of data. Notice the X axis starts at week 8 (23 February 1983) and finishes at week 7 (15 February 1984) to correspond with the last year of data in column four of Table I.

1. General Comments

Figure A.1 substantiates price rises during the summer months (summer meat). Figure A.2 shows that, on an average, week 15 starts the climb which continues until week 29 when the apex is reached. A steady fall then occurs until week 40. Another significant and unexpected (according to the summer meat theory) price movement occurs in week 46. The price rise continues until week 1 of the following year whereupon a decrease in price occurs which continues until week 5. This unexpected price movement was checked with Meat Price Relationships [Ref. 9] which was found to have similar results. The seasonal indices in Figure A.3 provide additional support of price movements and translates the movements into percentages of the average yearly price.

2. Forecast Results

Referring to Figure A.4, Forecast Method 1 (the Four Week Moving Average), due to its very nature, lagged during price increases and decreases. The Mean Absolute Percentage Error (MAPE) was 4.35%. Its ability to predict turning points was very poor (a prime consideration if it is going to be useful for IMB managers). A correction factor would be necessary to better align the predictions. Because of this, it may be better to use the average curve and anticipate price movements based on time of the year. Forecast Method 2 (Decomposition Method) at first appears to be very volatile, (it is based on Figure A.3). However, it does a much better job of predicting turning points. The MAPE using this method was 2.72% representing another slight improvement in accuracy versus Method 1. These findings are in accord with The Beginning Forecaster [Ref. 11 : p.23]. Perhaps if the seasonal indices were constructed using more

years of data (at least 5 rather than 3 as used in this study), a less volatile and more reliable forecast would result. If it was used, IMB managers would be faced with reacting to "ghostly" price movements. This method has potential if more data could be obtained.

3. Conclusions

Forecast Method 2 exhibits promise if an enlarged data base is obtained. In the interim, IMB managers could use the general "rule of thumb" of knowing what week of the year it is in relation to price movements. By using Figure A.2 in Appendix A, IMB managers could expedite purchases (assuming the luxury exists of having a choice between purchasing or delaying) during periods of price rises, delay purchases during periods of price decreases and ideally try to purchase quantities during historically seasonal low points of the year.

C. STRIP LOIN (IMPS. 180)

1. General Comments

Figure B.1 substantiates price rises during the summer months (summer meat). There appeared to be three outliers with the following midpoints that had a significant impact upon the resulting seasonal indices and Forecast Method 2: week 14 of 1982 (April 7_3.48), week 27 of 1981 (July 8_3.78), and week 32 of 1982 (Aug. 11_2.78). Checking the same periods in Meat Price Relationships [Ref. 9] revealed less significant changes. Figure B.2 shows that by averaging the data, a smoother data pattern is attained. Week 15 starts the steady climb of prices until a plateau is reached at week 23. A period of relatively level prices (approx. 10 weeks) continues through the summer months. After approximately week 34, prices start to decline at a significant rate.

2. Forecast Results

Referring to Figure B.4, Forecast Method 1 did very well during level periods as would be expected but once again failed to predict turning points. This method lagged during price fluctuations. Forecast Method 2 was experiencing "ghostly" turning points due to insufficient data (note Figure B.3 and the volatility) but was better able to predict turning points than Method 1. The MAPE using Forecast Method 1 was 2.98% versus 3.44% using Forecast Method 2. However, because Forecast Method 2 was better able to predict turning points it has greater potential than Method 1.

3. Conclusions

Until a smoothing of the seasonal indices can be developed by using more data, Forecast Method 2 is not recommended. Once again the "rule of thumb" is recommended in the interim. Figure B.2 in Appendix B would be useful to IMB managers in this regard.

Because Strip Loin has a substantial average yearly demand of over 1,250,000 pounds and a shelf life of 10 months, there exists the possibility to stockpile this item prior to the significant summer price increase. The price differential can be over 40% from pre-summer months to summer months.

Offsetting this potential gain would be the associated holding costs incurred because of the increase in inventory. Could current cold storage facilities handle an increase in inventory? What percentage of demand occurs during the summer months? These are issues which would necessitate an economic analysis to determine its feasibility.

D. TCP SIRLOIN (IMPS. 184)

1. General Comments

Figure C.1 illustrates a strong summer meat concept. Figure C.2 shows the four-year average. There appears to be a consistent dip in price during weeks 3 and 4 of every year. Beginning in Week 5 the price starts to rise, reaching a plateau in approximately week 20. The plateau lasts 6 weeks whereupon a slight decline occurs for the next 4 weeks. This is followed by a slight increase until week 35 when a significant decrease in price occurs and continues until week 45.

2. Forecast Results

Referring to Figure C.4, Forecast Method 1 continues to lag. During periods of horizontal movements, this method does quite well. Forecast Method 2 is once again able to predict turning points but again produces unreliable "ghostly" movements as well. The MAPE using either method was approximately the same 3.90%.

3. Conclusions

Forecast Method 2 once again exhibits potential provided a larger data base is acquired. In the interim, the "rule of thumb" method is recommended for implementation. Figure C.2 in Appendix C would be useful to IMB managers in this regard.

Because Top Sirloin has a significant price differential during the year (approximately 40%), it also would be a potential candidate for stockpiling. The same issues would apply as previously stated. Further study is needed to determine the best acquisition strategy.

B. TCP (INSIDE) ROUND (IMPS. 168)

1. General Comments

Figure D.1 illustrates the volatile nature of this product during any given week. Figure D.2 represents the "average" data behavior. There appears to be one significant period of higher prices. Starting in approximately week 13, the price rises until it reaches an apex in week 23. The price then begins to fall, returning to the previous level approximately by week 30.

2. Forecast Results

Referring to Figure D.4, Forecast Method 1 was unable to predict the beginning of the significant price increase (week 13--April 1st) due to the nature of its construction. Forecast Method 2 derived from Figure D.3 performed quite well. It appears to consistently predict turning points throughout the year. It reflected the significant price increase during the month of April with its only fault being that it continued to escalate during the month of May when in reality the price decline had started. Forecast Method 2 shows great promise provided a larger data base could be obtained to refine the seasonal indices. The MAPE using Forecast Method 1 was 3.95% versus 3.40% using Forecast Method 2.

3. Conclusions

Forecast Method 2 once again exhibits potential provided a larger data base is acquired. In the interim, the "rule of thumb" method is recommended for implementation. Figure D.2 in Appendix D would be useful to IMB managers in this regard.

Top Round has a significant average yearly demand of 3,675,000 pounds, the largest of the 5 products analyzed.

It also should be considered a candidate for stockpiling, thereby avoiding purchases during the 15 week range of significantly increased prices.

F. CHUCK ROLL (IMPS. 116A)

1. General Comments

Figure E.1 illustrates that Chuck Roll is rather volatile from week to week with a significantly narrower price range during the course of the year than the other four products analyzed. The winter meat concept is not as apparent in Chuck Roll as the summer meat concept was in Rib and loin primals. Figure E.2 represents a rather flat change in price with perhaps a minor increase in price during the months of January and February.

2. Forecast Results

Referring to Figure E.4, Forecast Method 1 was able to perform quite well due to the relatively flat change in price during the course of the year. Forecast Method 2 suffered once again from the insufficient data base in its construction. The MAPE using Forecast Method 1 was 3.00% versus 2.61% using Forecast Method 2.

3. Conclusions

A minor price increase occurs during the period of January and February. A suggested "rule of thumb" would be to avoid or delay purchases if given a choice during January and February. Although the relative price change during the year is not as dramatic as the previous four products, the extremely large quantities purchased during the year make it a candidate for cost efficiency analysis.

G. CONCLUSION

At this point in the developmental stage of a forecasting technique to capitalize on price movements, it appears that application of the "rules of thumb" would best serve IMB managers. A larger data base along with additional testing for accuracy and reliability would be necessary prior to implementation of Forecast Method 2.

Stockpiling during periods of historically low seasonal prices of Strip Loin, Top Sirloin, Top (Inside) Round, Ribeye Roll, and perhaps even Chuck Roll, may be an effective acquisition strategy. An economic analysis would be necessary prior to a major shift in acquisition policy.

H. SUMMARY

This chapter provided an in-depth cost analysis of Ribeye Roll, Strip Loin, Top Sirloin, Top (Inside) Round, and Chuck Roll using the two forecasting models proposed in Chapter III. In addition, the accuracy and reliability of these models were assessed. General "rules of thumb" were suggested for immediate use by IMB managers.

V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

As noted in Chapter I, the objectives of this thesis were: to confirm the existence of price movements within selected products for analysis, to seek knowledge that could supplement DSRPAC's (IMB) decision making for replenishment of inventory, and to develop a forecasting model that would predict price movements with a reasonable degree of accuracy and could easily be integrated within the current organizational structure of DSRPAC.

An overview of the major elements of the present operations of the meat supply system at DSRPAC was provided in Chapter II. Chapter III described data procurement and laid the foundation for the development of forecasting models that would predict price movements with a reasonable degree of accuracy. Chapter IV provided an in-depth cost analysis of the selected items and assessed the reliability and accuracy of the two forecasting models proposed in Chapter III.

B. CONCLUSIONS

1. Objective One

As illustrated in Appendices A through E, there exists significant seasonal price movements in four of the five products analyzed: Ribeye Roll, Strip Loin, Top Sirloin, and Top (Inside) Round. In the remaining product, Chuck Roll, there exists a minor seasonal price change during January and February.

2. Objective Two

By "knowing" how the cost of a stock item behaves in the market place during the course of the year, an IMB manager is in a much better position to evaluate the financial implications of any proposed replenishment decision.

IMB managers could expedite purchases (assuming the luxury exists of having a choice between purchasing or delaying) during periods of price rises, delay during periods of price decreases and ideally purchase quantities during historically seasonal low points of the year. Specifically;

a. Ribeye Roll (IMPS. 112A)

Figure A.2 shows that, on the average, costs start to climb by week 15 and continue until approximately week 29 when the apex is reached. A steady fall then occurs until approximately week 40. Another price increase occurs around week 46. The price rises until week 1 of the following year after which a decrease in price occurs until week 5.

b. Strip Loin (IMPS. 180)

Figure B.2 shows that, on the average, week 15 marks the beginning of a steady climb of prices which continues until a plateau is reached at week 23. A period of relative level prices continues for approximately 10 weeks. Week 34 starts the decline of prices at a significant rate.

c. Top Sirloin (IMPS. 184)

Figure C.2 shows that, on the average, by week 3 the price starts to climb, reaching a plateau at approximately week 20. The plateau lasts 6 weeks after which a

slight decline occurs for the next 4 weeks. This is followed by a slight increase until week 35 when a significant decrease in price occurs and continues until week 3 of the following year.

d. Top (Inside) Round (IMPS. 168)

Figure D.2 shows that, on the average, there is a significant period of higher prices between weeks 15 and week 30. Starting at approximately week 15, the price climbs until reaching an apex at week 23. The price then begins to fall returning to the previous level by week 30.

e. Chuck Roll (IMPS. 116A)

Figure E.2 shows that, on the average, the price movement is rather insignificant during the year. There exists a small increase in price during January and February.

As noted in Chapter II, IMB manager's performance evaluations are based on supply effectiveness and inventory turnover rate. Acquisition strategy involving price movements would require top management's attention to become an integral part of the acquisition strategy and part of the performance evaluation of the IMB managers.

3. Objective Three

The results of Chapter IV suggest that it is premature to propose either the Four Week Moving Average or the Decomposition Method as a forecasting model. However, the latter offers great promise for future implementation by DSRPAC. It currently fulfills the requirements of low cost, simplicity, short-term extrapolation capability, and a readily available data source. A larger data base along with additional testing for accuracy and reliability would be necessary prior to implementation of the Decomposition Method.

C. RECOMMENDATIONS

The Federal Budget continues to grow, forcing an internal re-evaluation of methods and policies consistent with efficient allocation of limited resources (\$). It has been shown that significant seasonal price movements occur for selected stock items of beef. These price movements should be incorporated into the acquisition strategy of DSRPAC. An immediate implementation would be the use of the "rules of thumb" based on what appears to be consistent seasonal periods of rising or falling prices.

The Decomposition Method offers great promise for future implementation by DSEPAC. Further experimentation with a larger data base is recommended.

Finally, stockpiling during periods of historically low seasonal prices may be an effective acquisition strategy. An economic analysis would be necessary prior to making such a shift in acquisition policy.

The criterion of supply effectiveness should always be foremost, consistent with DSRPAC's purpose, but need not be degraded by the introduction of cost efficiencies associated with an acquisition strategy that considers price movements.

APPENDIX A

RIBEYE ROLL, LIP-ON BEEF (IMPS.112A) DATA

TABLE I
Ribeye Roll, Lip-on Beef

U.S. Choice Grade, IMPS. Item No. 112A
Actual Costs in Dollars per Pound

<u>1980/81</u>	<u>1981/82</u>	<u>1982/83</u>	<u>1983/84</u>
FEB. 27 3.20	FEB. 25 2.99	FEB. 24 3.23	FEB. 23 2.92
MAR. 5 3.25	MAR. 4 3.00	MAR. 3 3.23	MAR. 2 2.82
12 3.25	11 2.98	10 3.31	9 2.93
19 3.20	18 2.93	17 3.33	16 2.97
26 3.10	25 2.90	24 3.28	23 3.03
APR. 2 3.00	APR. 1 2.83	31 3.36	30 3.12
9 3.05	8 2.93	APR. 7 3.68	APR. 6 3.16
16 2.95	15 2.93	14 3.43	13 3.26
23 3.00	22 2.98	21 3.42	20 3.33
30 3.00	29 3.00	28 3.42	27 3.42
MAY 7 3.00	MAY 6 3.23	MAY 5 3.53	MAY 4 3.45
14 3.13	13 3.51	12 3.58	11 3.42
21 3.08	20 3.41	19 3.63	18 3.44
28 3.13	27 3.36	26 3.61	25 3.49
JUNE 4 3.17	JUNE 3 3.00	JUNE 2 3.68	JUNE 1 3.51
11 3.20	10 3.25	9 3.53	8 3.57
18 3.20	17 3.37	16 3.63	15 3.58
25 3.20	24 3.53	23 3.65	22 3.60
JULY 2 3.00	JULY 1 3.58	30 3.71	29 3.62
9 3.50	8 3.68	JULY 7 3.73	JULY 6 3.66
16 3.60	15 3.77	14 3.83	13 3.70
23 3.60	22 3.53	21 3.75	20 3.78
30 3.60	29 3.50	28 3.80	27 3.81
AUG. 6 3.63	AUG. 5 3.58	AUG. 4 3.73	AUG. 3 3.71
13 3.70	12 3.55	11 3.58	10 3.58
20 3.72	19 3.58	18 3.63	17 3.65
27 3.75	26 3.58	25 3.55	24 3.57
SEP. 3 3.80	SEP. 2 3.53	SEP. 1 3.58	31 3.55
10 3.70	9 3.38	8 3.53	SEP. 7 3.49
17 3.65	16 3.38	15 3.38	14 3.46
24 3.55	23 3.38	22 3.26	21 3.45
OCT. 1 3.43	30 3.30	29 3.13	28 3.25
8 3.40	OCT. 7 3.25	OCT. 6 3.93	OCT. 5 3.05
15 3.33	14 3.20	13 3.05	12 3.14
22 3.33	21 3.25	20 3.97	19 3.16
29 3.58	28 3.15	27 3.20	26 3.15
NOV. 5 3.33	NOV. 4 3.17	NOV. 3 3.24	NOV. 2 3.20
12 3.48	11 3.11	10 3.24	9 3.21
19 3.43	18 3.11	17 3.12	16 3.21
26 3.33	25 3.10	24 3.11	23 3.25
DEC. 3 3.23	DEC. 2 3.23	DEC. 1 3.08	30 3.21
10 3.18	9 3.38	8 3.05	DEC. 7 3.32
17 3.13	16 3.38	15 3.10	14 3.50
24 3.11	23 3.41	22 3.18	21 3.71
31 3.25	30 3.51	29 3.07	28 3.84
JAN. 7 3.25	JAN. 6 3.68	JAN. 5 3.06	JAN. 4 3.95
14 3.33	13 3.33	12 3.11	11 4.17
21 3.03	20 3.38	19 2.88	18 3.92
28 3.96	27 3.27	26 2.96	25 3.65
FEB. 4 3.00	FEB. 3 3.08	FEB. 2 3.06	FEB. 1 3.38
11 3.96	10 3.98	9 3.97	8 3.31
18 2.88	17 3.03	16 2.96	15 3.21

TABLE II
Ribeye Rcll, Lip-on Beef (INPS.112A)

<u>Forecast 1</u>	<u>Forecast 2</u>	<u>Avg. Cost</u>	<u>Season Ind.</u>
(<u>\$</u>)	(<u>\$</u>)	(<u>\$</u>)	(<u>%</u>)
FEB. 23 2.99	FEB. 23 2.94	WEEK 1 3.49	WEEK 1 1.03
MAR. 2 2.98	MAR. 2 2.94	2 3.49	2 0.99
16 2.92	16 2.83	3 3.30	3 0.95
30 2.91	30 2.93	4 3.21	4 0.93
APR. 6 2.94	APR. 6 3.00	5 3.14	5 0.91
13 3.07	13 3.33	6 3.06	6 0.88
20 3.14	20 3.00	7 3.02	7 0.88
MAY 4 3.22	MAY 4 3.41	8 3.09	8 0.93
11 3.37	11 3.59	9 3.08	9 0.93
18 3.41	18 3.62	10 3.12	10 0.94
25 3.43	25 3.40	11 3.11	11 0.93
JUNE 1 3.47	JUNE 1 3.50	12 3.08	12 0.92
8 3.50	8 3.41	13 3.08	13 0.92
15 3.54	15 3.41	14 3.18	14 0.99
22 3.57	22 3.66	15 3.14	15 0.95
JULY 6 3.59	JULY 6 3.66	16 3.15	16 0.94
13 3.62	13 3.66	17 3.22	17 0.97
20 3.65	20 3.64	18 3.30	18 1.01
AUG. 3 3.74	AUG. 3 3.82	19 3.41	19 1.07
10 3.75	10 3.62	20 3.39	20 1.06
17 3.72	17 3.62	21 3.40	21 1.05
SEP. 7 3.63	SEP. 7 3.43	22 3.42	22 1.05
14 3.52	14 3.66	23 3.49	23 1.02
21 3.52	21 3.66	24 3.55	24 1.05
OCT. 5 3.30	OCT. 5 3.21	25 3.50	25 1.08
12 3.44	12 3.19	26 3.58	26 1.10
19 3.22	19 3.18	27 3.64	27 1.12
26 3.15	26 3.21	28 3.68	28 1.12
NOV. 9 3.33	NOV. 9 3.33	29 3.67	29 1.10
16 3.18	16 3.18	30 3.68	30 1.10
23 3.22	23 3.27	31 3.66	31 1.10
DEC. 7 3.22	DEC. 7 3.25	32 3.60	32 1.08
14 3.25	14 3.29	33 3.61	33 1.11
21 3.32	21 3.33	34 3.62	34 1.11
JAN. 5 3.44	JAN. 5 3.40	35 3.62	35 1.11
12 3.55	12 3.48	36 3.53	36 1.08
19 3.92	19 3.80	37 3.49	37 1.07
FEB. 1 3.78	FEB. 1 3.88	38 3.39	38 1.04
8 3.57	8 3.29	39 3.22	39 1.02
		40 3.16	40 1.01
		41 3.18	41 1.00
		42 3.19	42 1.00
		43 3.29	43 1.02
		44 3.26	44 1.01
		45 3.22	45 1.00
		46 3.22	46 1.00
		47 3.19	47 1.00
		48 3.23	48 1.00
		49 3.28	49 1.00
		50 3.37	50 1.00
		51 3.42	51 1.01
			52 1.01
MAPE 4.35	MAPE 2.72		

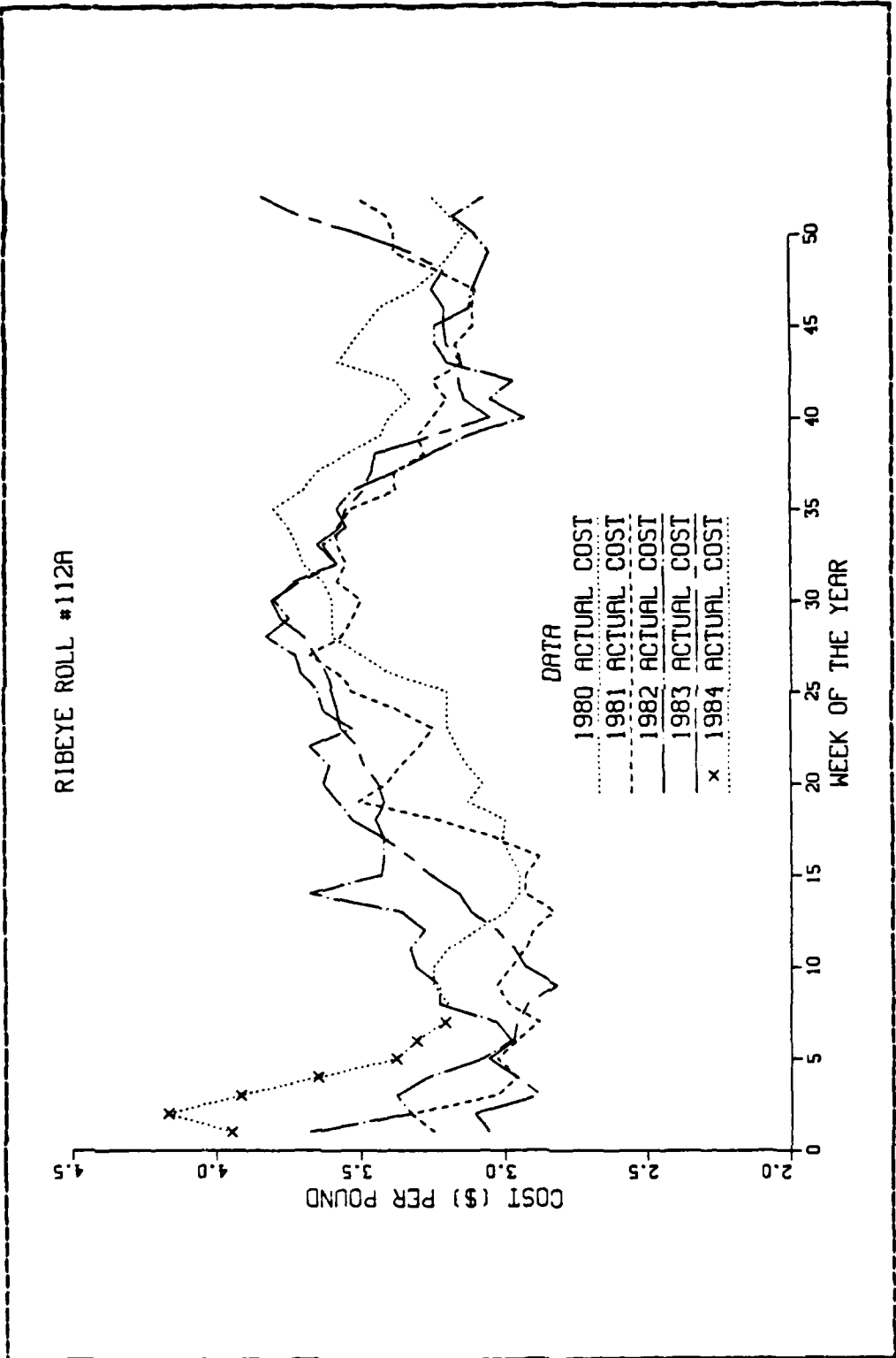


Figure A.1 Cost Data for Ribeye Roll (IMPS.112A).

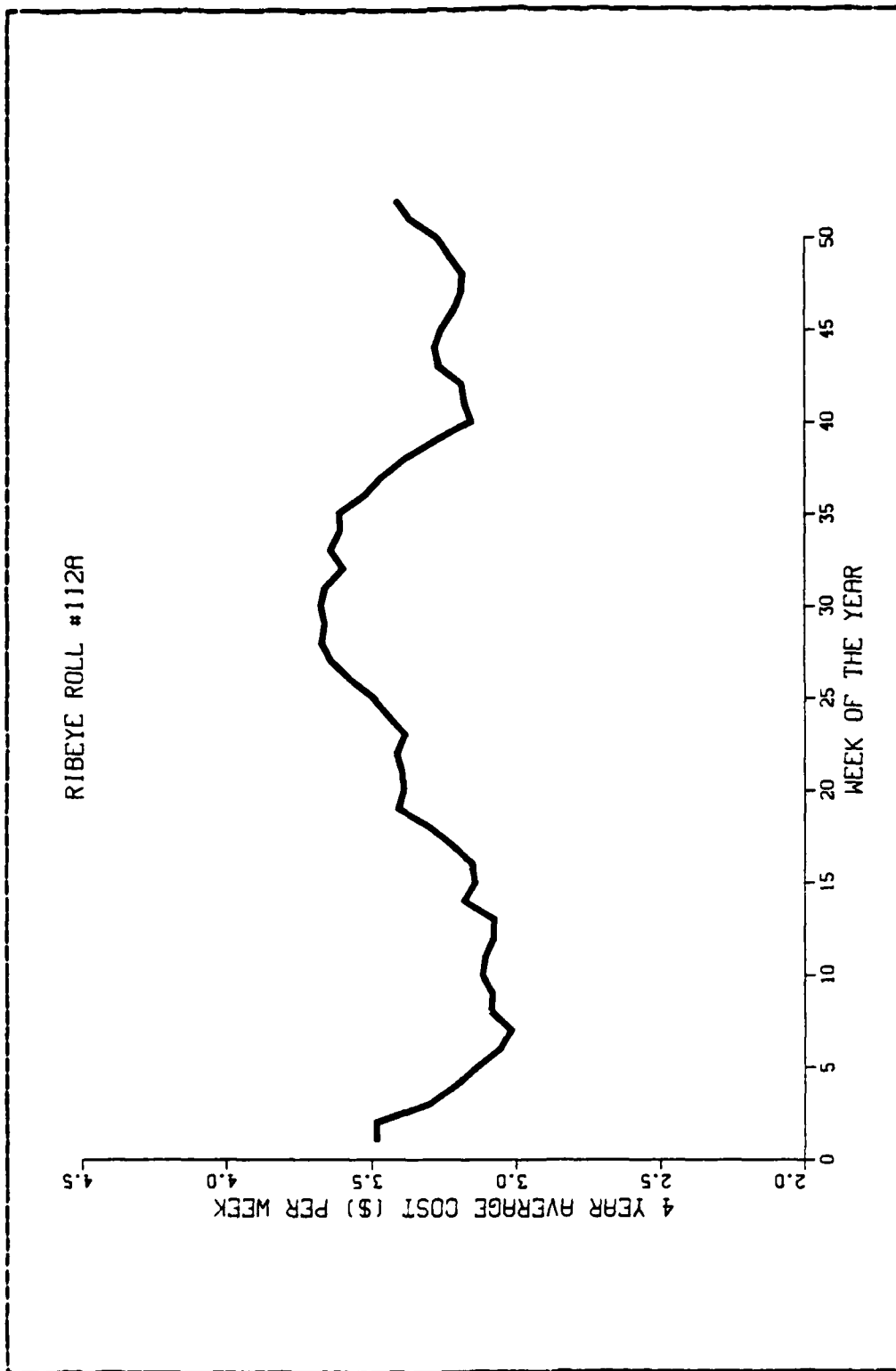


Figure A.2 Average Cost per Week for Ribeye Roll (IMPS.112A).

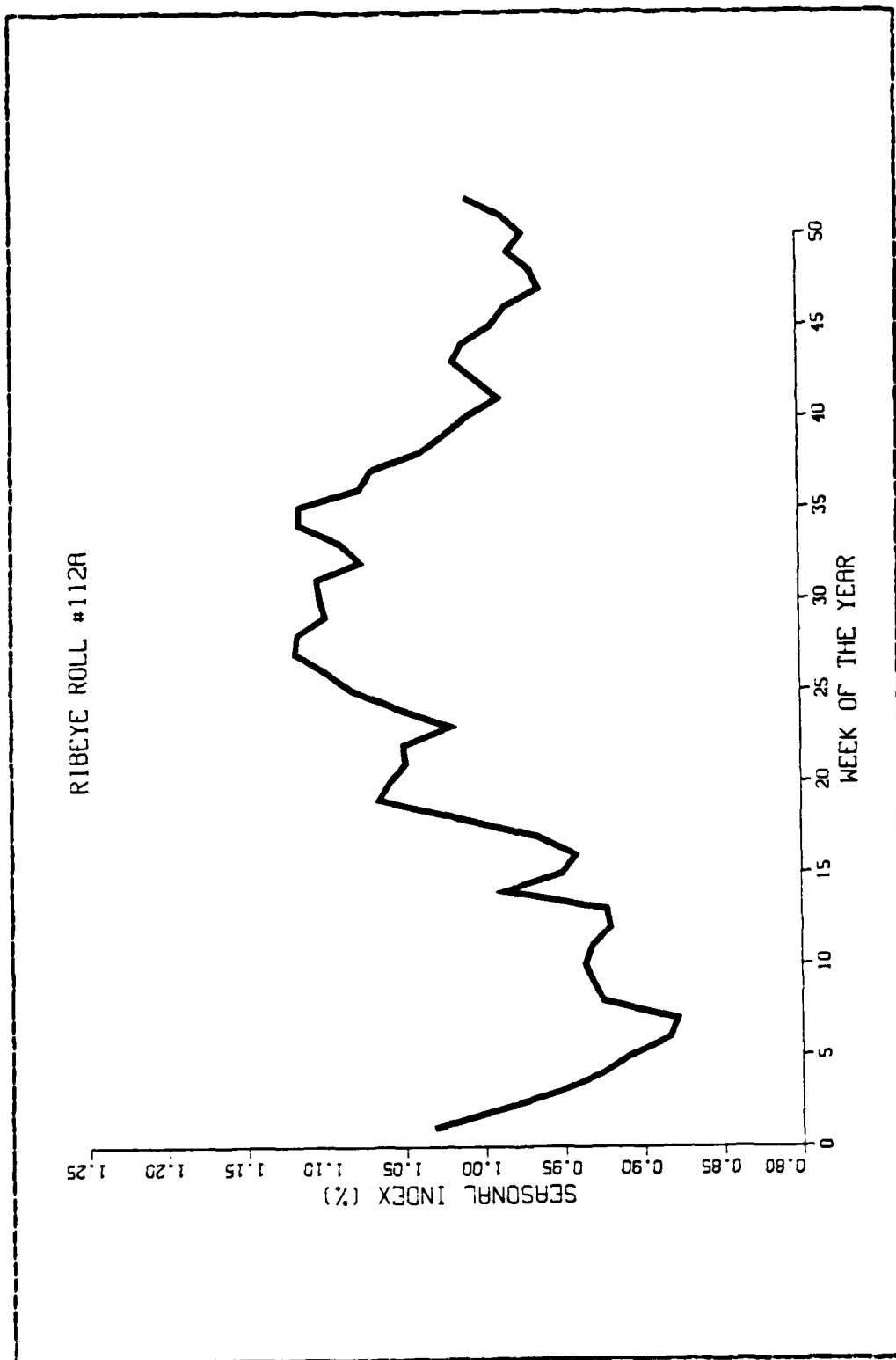


Figure A.3 Seasonal Index for Ribeye Roll (IMPS.112A) -

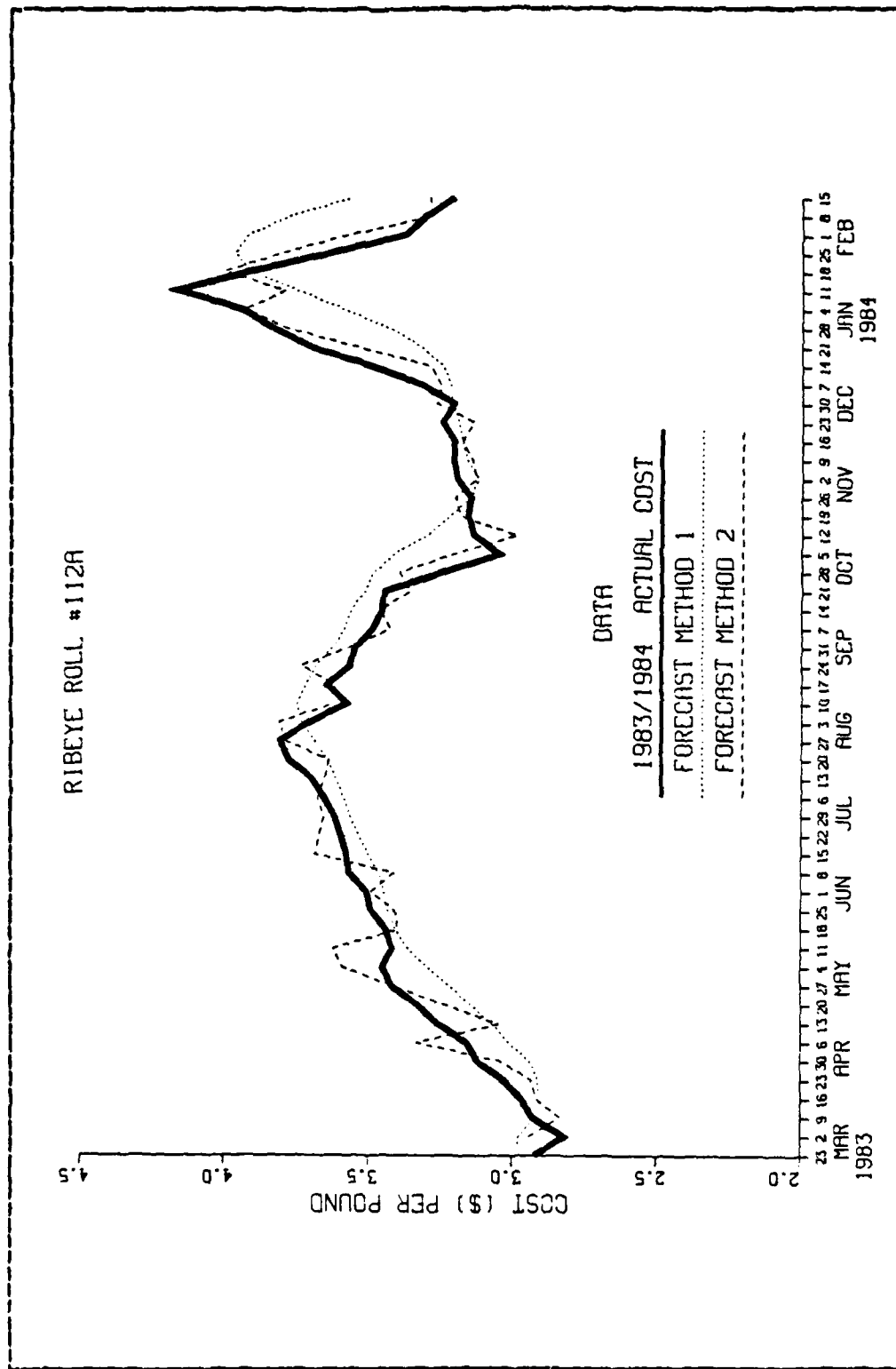


Figure A.4 Comparison of Forecast Methods for Ribeye Roll (IMPS.112A).

APPENDIX B

BCNELESS, SHORTCUT, STRIP LCIN BEEF (IMPS.180) DATA

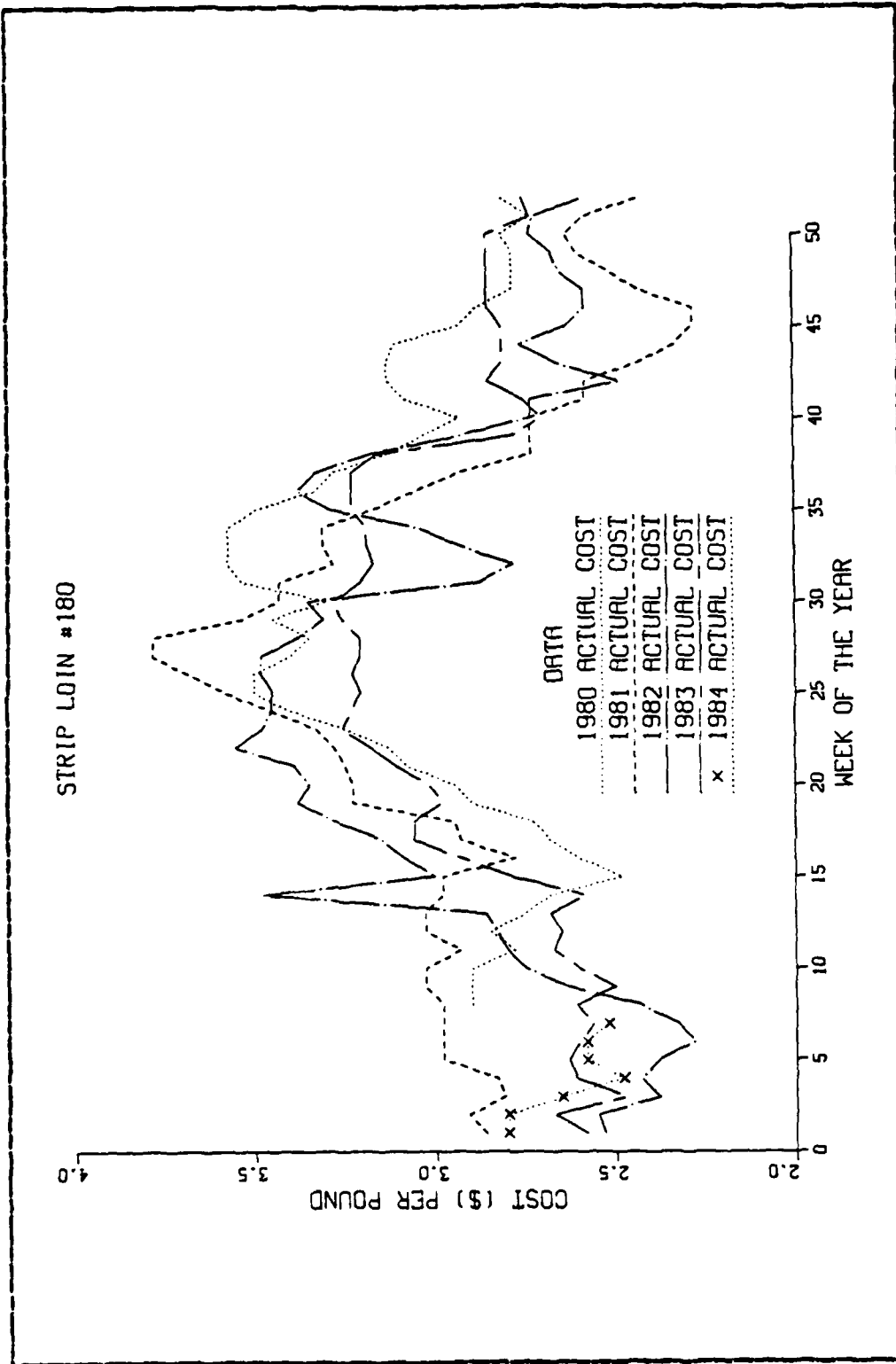
TABLE III
Boneless, Shortcut, Strip Loin Beef

U.S. Choice Grade, IMPS. Item No. 180
 Actual Costs in Dollars per Pound

<u>1980/81</u>	<u>1981/82</u>	<u>1982/83</u>	<u>1983/84</u>
FEB. 27 2.90	FEB. 25 2.98	FEB. 24 2.43	FEB. 23 2.61
MAR. 5 2.90	MAR. 4 3.00	MAR. 3 2.63	MAR. 2 2.50
12 2.90	11 3.00	10 2.75	9 2.60
19 2.78	18 2.93	17 2.80	16 2.67
26 2.85	25 3.00	24 2.83	23 2.65
APR. 2 2.75	APR. 1 3.00	31 2.86	30 2.68
9 2.68	8 2.98	APR. 7 3.48	APR. 6 2.58
16 2.48	15 2.98	14 3.00	13 2.79
23 2.60	22 2.78	21 3.09	20 2.93
30 2.68	29 2.95	28 3.15	27 3.06
MAY 7 2.73	MAY 6 2.95	MAY 5 3.28	MAY 4 3.06
14 2.90	13 3.23	12 3.38	11 2.98
21 2.95	20 3.25	19 3.35	18 3.02
28 2.08	27 3.25	26 3.39	25 3.11
JUNE 4 2.13	JUNE 3 3.25	JUNE 2 3.55	JUNE 1 3.18
11 2.25	10 3.33	9 3.48	8 3.26
18 2.40	17 3.45	16 3.45	15 3.23
25 2.50	24 3.58	23 3.45	22 3.21
JULY 2 2.50	JULY 1 3.68	30 3.48	29 3.23
9 2.40	8 3.78	JULY 7 3.48	JULY 6 3.21
16 2.35	15 3.78	14 3.38	13 3.21
23 2.45	22 3.55	21 3.33	20 3.26
30 2.50	29 3.43	28 3.35	27 3.28
AUG. 6 2.53	AUG. 5 3.43	AUG. 4 3.88	AUG. 3 3.21
13 2.57	12 3.48	11 2.78	10 3.17
20 2.57	19 3.33	18 2.93	17 3.19
27 2.49	26 3.33	25 3.05	24 3.19
SEP. 3 2.33	SEP. 2 3.17	SEP. 1 3.29	31 3.23
10 2.33	9 3.05	8 3.38	SEP. 7 3.23
17 2.28	16 2.99	15 3.33	14 3.23
24 2.13	23 2.77	22 3.18	21 3.16
OCT. 1 2.93	OCT. 30 2.77	29 2.93	28 2.78
8 2.93	14 2.55	OCT. 6 2.73	OCT. 5 2.70
15 2.98	21 2.58	13 2.73	12 2.75
22 2.13	28 2.43	20 2.48	19 2.85
29 2.13	NOV. 4 2.33	27 2.66	26 2.81
NOV. 5 2.11	11 2.33	NOV. 3 2.76	NOV. 2 2.81
12 2.93	18 2.22	10 2.63	9 2.81
19 2.88	25 2.45	17 2.58	16 2.85
26 2.78	DEC. 2 2.51	24 2.58	23 2.85
DEC. 3 2.78	9 2.60	DEC. 1 2.65	30 2.85
10 2.78	16 2.63	8 2.67	DEC. 7 2.85
17 2.81	23 2.63	15 2.73	14 2.85
24 2.73	30 2.45	22 2.72	21 2.73
31 2.81	JAN. 6 2.55	29 2.58	JAN. 28 2.75
JAN. 7 2.86	13 2.55	JAN. 5 2.58	JAN. 4 2.80
14 2.91	20 2.58	12 2.67	11 2.80
21 2.81	27 2.58	19 2.47	18 2.65
28 2.83	FEB. 3 2.33	26 2.61	25 2.48
FEB. 4 2.98	10 2.33	FEB. 2 2.63	FEB. 1 2.58
11 2.98	17 2.33	9 2.60	8 2.58
18 2.98		16 2.56	15 2.52

TABLE IV
Poneless, Shortcut, Strip Loin Beef (IMPS. 180)

<u>Forecast 1</u>	<u>Forecast 2</u>	<u>Avg. Cost</u>	<u>Season Ind.</u>
(<u>\$</u>)	(<u>\$</u>)	(<u>\$</u>)	(<u>%</u>)
FEB. 23	FEB. 23	WEEK 1	WEEK 1
MAR. 2	MAR. 2	2	2
9	9	3	3
16	16	4	4
23	23	5	5
30	30	6	6
APR. 6	APR. 6	7	7
13	13	8	8
20	20	9	9
27	27	10	10
MAY 4	MAY 4	11	11
11	11	12	12
18	18	13	13
25	25	14	14
JUNE 1	JUNE 1	15	15
8	8	16	16
15	15	17	17
22	22	18	18
JULY 6	JULY 6	19	19
13	13	20	20
20	20	21	21
27	27	22	22
AUG. 3	AUG. 3	23	23
10	10	24	24
17	17	25	25
24	24	26	26
SEP. 7	SEP. 7	27	27
14	14	28	28
21	21	29	29
28	28	30	30
OCT. 5	OCT. 5	31	31
12	12	32	32
19	19	33	33
26	26	34	34
NOV. 2	NOV. 2	35	35
9	9	36	36
16	16	37	37
23	23	38	38
30	30	39	39
DEC. 7	DEC. 7	40	40
14	14	41	41
21	21	42	42
28	28	43	43
JAN. 4	JAN. 4	44	44
11	11	45	45
18	18	46	46
25	25	47	47
FEB. 1	FEB. 1	48	48
8	8	49	49
15	15	50	50
		51	51
		52	52
MAPE <u>2.98</u>	MAPE <u>3.44</u>		



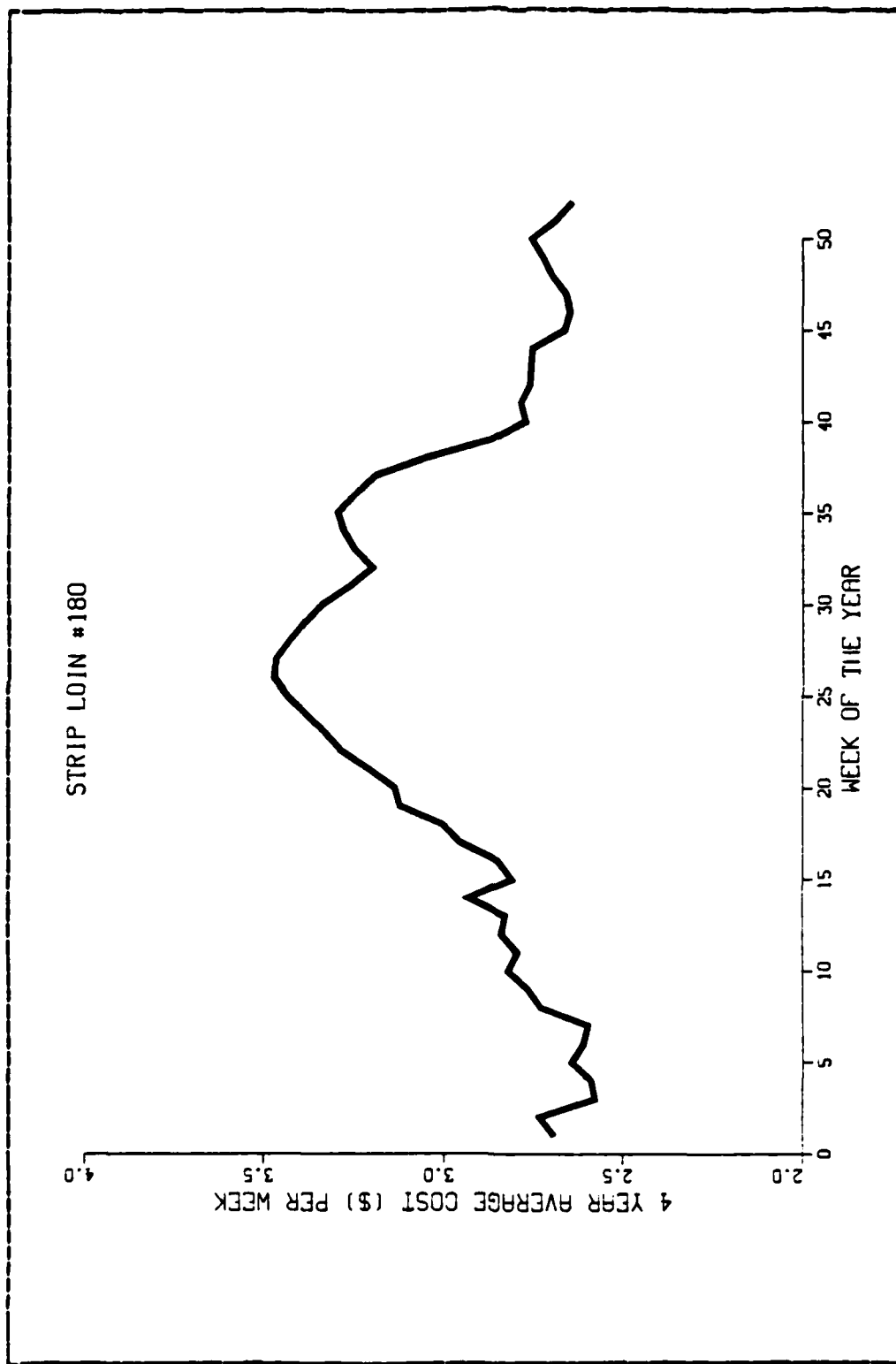


Figure B.2 Average Cost per Week for Strip Loin (IMPS.180).

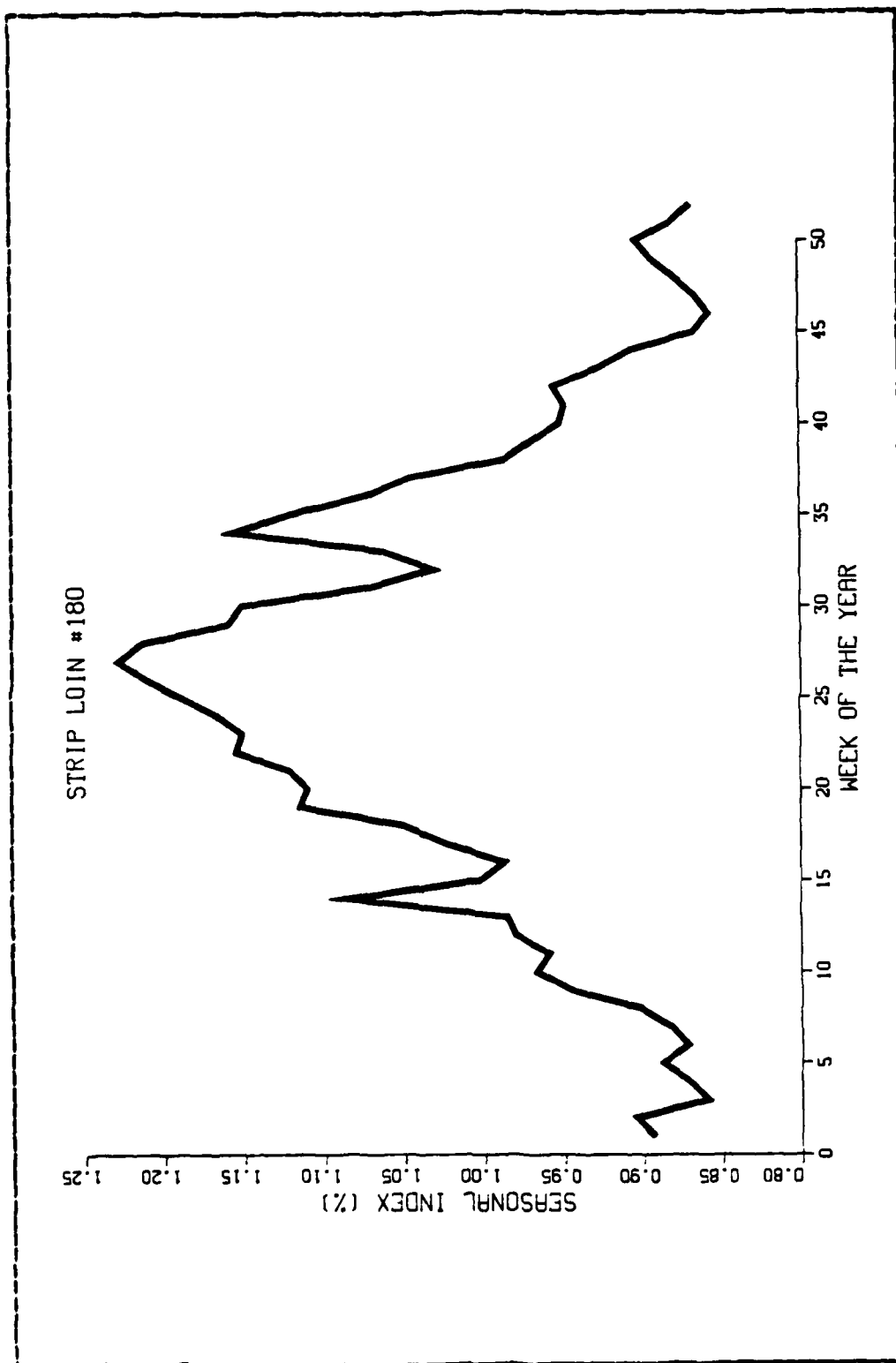


Figure B.3 Seasonal Index for Strip Loin (INPS.180).

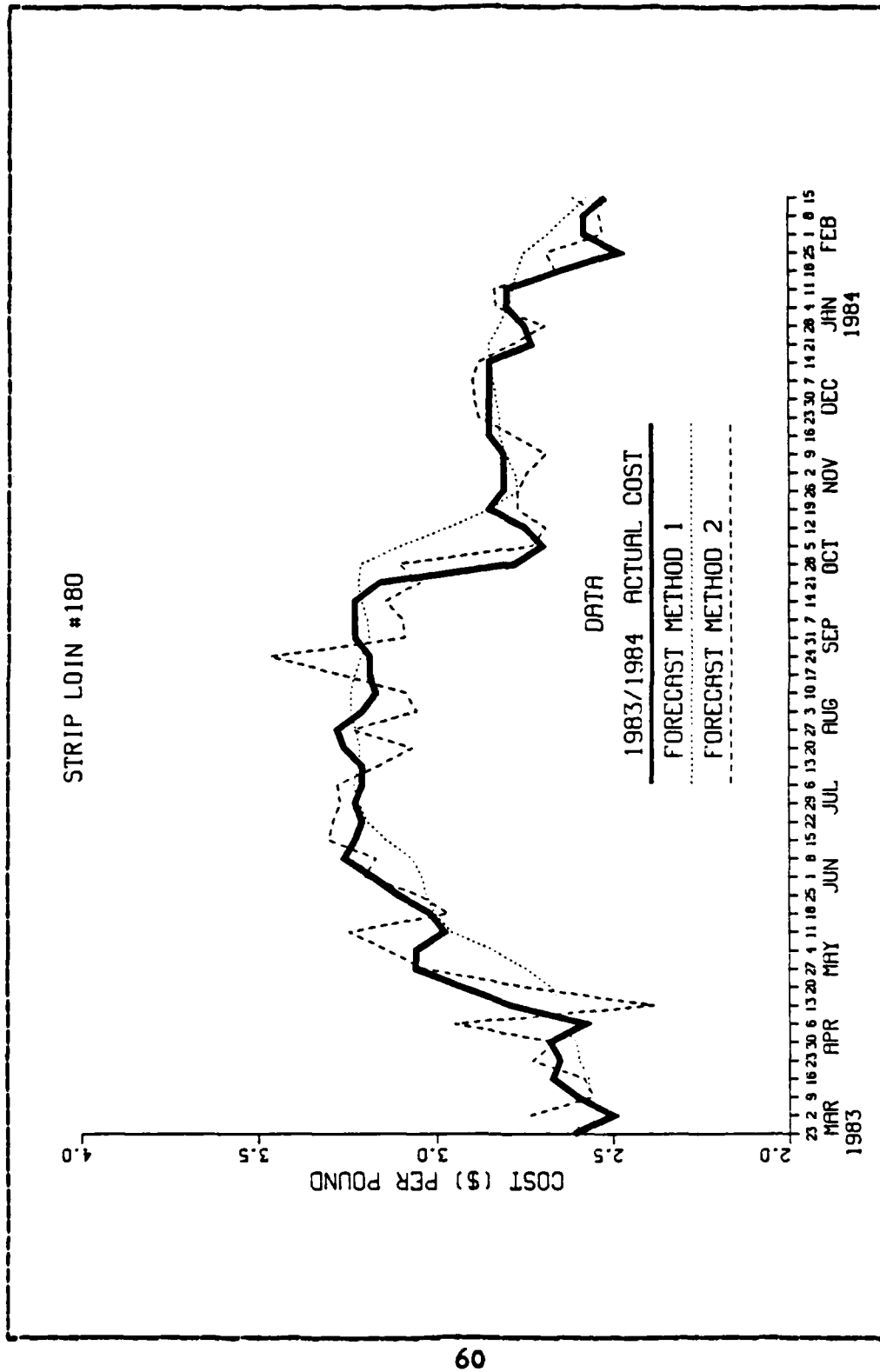


Figure B.4 Comparison of Forecast Methods for Strip Loin (IMPS.180).

APPENDIX C

TOP SIRLOIN BUTT BEEF (IMPS.184) DATA

TABLE V
Top Sirloin Butt Beef

U.S. Choice Grade, IMPS. Item No. 184
Actual Ccsts in Dcllars per Pound

<u>1980/81</u>	<u>1981/82</u>	<u>1982/83</u>	<u>1983/84</u>
FEB. 27 2.13	FEB. 25 1.97	FEB. 24 1.87	FEB. 23 1.95
MAR. 15 2.30	MAR. 4 2.03	MAR. 3 1.93	MAR. 2 1.87
12 2.35	11 2.03	10 2.11	9 1.98
19 2.38	18 2.03	17 2.15	16 2.04
26 2.38	25 2.08	24 2.00	23 2.08
APR. 2 2.23	APR. 1 2.08	31 2.25	30 2.13
9 2.18	8 2.05	APR. 7 2.48	APR. 6 2.06
16 2.05	15 2.05	14 2.33	13 2.18
23 2.11	22 1.93	21 2.40	20 2.25
30 2.18	29 2.12	28 2.33	27 2.33
MAY 7 2.16	MAY 6 2.18	MAY 5 2.43	MAY 4 2.26
14 2.28	13 2.35	12 2.53	11 2.22
21 2.39	20 2.35	19 2.55	18 2.26
28 2.50	27 2.33	26 2.40	25 2.35
JUNE 4 2.50	JUNE 3 2.38	JUNE 2 2.53	JUNE 1 2.39
11 2.48	10 2.38	9 2.51	8 2.43
18 2.55	17 2.45	16 2.53	15 2.37
25 2.40	24 2.63	23 2.53	22 2.36
JULY 2 2.45	JULY 1 2.68	30 2.48	29 2.34
9 2.55	8 2.67	JULY 7 2.48	JULY 6 2.36
16 2.38	15 2.53	14 2.38	13 2.39
23 2.39	22 2.43	21 2.33	20 2.43
30 2.38	29 2.33	28 2.39	27 2.44
AUG. 6 2.50	AUG. 5 2.19	AUG. 4 2.31	AUG. 3 2.40
13 2.57	12 2.40	11 2.31	10 2.35
20 2.57	19 2.45	18 2.40	17 2.36
27 2.57	26 2.48	25 2.41	24 2.36
SEP. 3 2.57	SEP. 2 2.43	SEP. 1 2.49	31 2.38
10 2.43	9 2.33	8 2.50	SEP. 7 2.39
17 2.33	16 2.30	15 2.35	14 2.34
24 2.30	23 2.38	22 2.21	21 2.35
OCT. 1 2.28	OCT. 30 2.23	29 2.07	28 2.18
8 2.18	7 2.18	OCT. 6 1.95	OCT. 5 2.09
15 2.23	14 2.00	13 1.87	12 2.14
22 2.33	21 2.00	20 1.68	19 2.18
29 2.30	28 1.88	27 1.91	26 2.13
NOV. 5 2.26	NOV. 4 1.83	NOV. 3 1.96	NOV. 2 2.13
12 2.11	11 1.75	10 1.96	9 2.03
19 2.00	18 1.71	17 1.76	16 1.93
26 2.03	25 1.79	24 1.68	23 1.76
DEC. 3 2.03	DEC. 2 1.86	DEC. 1 1.77	30 1.70
10 2.08	9 1.88	8 1.78	DEC. 7 1.76
17 2.00	16 1.78	15 1.68	14 1.88
24 1.93	23 1.72	22 1.73	21 1.78
JAN. 1 1.91	30 1.68	29 1.59	28 1.80
7 1.96	JAN. 6 1.83	JAN. 5 1.66	JAN. 4 1.82
14 1.98	13 1.83	12 1.76	11 1.83
21 1.86	20 1.65	19 1.66	18 1.74
28 1.98	27 1.78	26 1.80	25 1.76
FEB. 4 2.00	FEB. 3 1.65	FEB. 2 1.88	FEB. 1 1.96
11 1.95	10 1.68	9 1.92	8 2.04
18 1.95	17 1.77	16 1.97	15 2.14

TABLE VI
Top Sirloin Butt Beef (IMPS. 184)

<u>Forecast 1</u>	<u>Forecast 2</u>	<u>Avg. Cost</u>	<u>Season Ind.</u>
FEB. 23 (\$)	FEB. 23 (\$)	WEEK 1 (\$)	WEEK 1 (%)
MAR. 2-1.89	MAR. 2-2.01	2-1.86	2-0.87
9-1.93	9-1.96	3-1.73	3-0.88
16-1.94	16-2.00	4-1.83	4-0.86
23-1.96	23-1.99	5-1.87	5-0.84
30-1.99	30-2.21	6-1.90	6-0.83
APR. 6-2.06	APR. 6-2.23	7-1.96	7-0.86
13-2.08	13-1.99	8-1.98	8-0.88
20-2.11	20-2.16	9-2.03	9-0.91
27-2.16	27-2.32	10-2.12	10-0.95
MAY 4-2.21	MAY 4-2.42	11-2.15	11-0.96
11-2.26	11-2.39	12-2.14	12-0.94
18-2.27	18-2.23	13-2.17	13-1.00
25-2.27	25-2.18	14-2.19	14-1.05
JUNE 1-2.27	JUNE 1-2.44	15-2.15	15-1.01
8-2.31	8-2.38	16-2.17	16-1.00
15-2.36	15-2.48	17-2.24	17-1.03
22-2.39	22-2.46	18-2.26	18-1.07
29-2.39	29-2.36	19-2.35	19-1.14
JULY 6-2.38	JULY 6-2.34	20-2.39	20-1.14
13-2.36	13-2.25	21-2.40	21-1.10
20-2.36	20-2.32	22-2.45	22-1.15
27-2.38	27-2.44	23-2.45	23-1.14
AUG. 3-2.41	AUG. 3-2.30	24-2.48	24-1.17
10-2.42	10-2.51	25-2.48	25-1.21
17-2.41	17-2.42	26-2.49	26-1.21
24-2.39	24-2.40	27-2.49	27-1.21
31-2.37	31-2.34	28-2.42	28-1.16
SEP. 7-2.36	SEP. 7-2.27	29-2.40	29-1.12
14-2.37	14-2.33	30-2.40	30-1.12
21-2.37	21-2.27	31-2.35	31-1.06
28-2.37	28-2.37	32-2.41	32-1.11
OCT. 5-2.32	OCT. 5-2.11	33-2.45	33-1.14
12-2.24	12-2.04	34-2.46	34-1.16
19-2.19	19-2.14	35-2.47	35-1.15
26-2.15	26-2.13	36-2.41	36-1.10
NOV. 2-2.14	NOV. 2-2.08	37-2.33	37-1.07
9-2.15	9-2.01	38-2.26	38-1.04
16-2.12	16-1.95	39-2.19	39-1.04
23-2.06	23-1.99	40-2.10	40-1.01
30-1.96	30-1.79	41-2.07	41-0.98
DEC. 7-1.86	DEC. 7-1.73	42-2.03	42-0.98
14-1.79	14-1.68	43-2.06	43-0.96
21-1.78	21-1.81	44-2.05	44-0.94
28-1.78	28-1.75	45-1.96	45-0.89
JAN. 4-1.81	JAN. 4-1.90	46-1.85	46-0.85
11-1.82	11-1.84	47-1.82	47-0.88
18-1.81	18-1.68	48-1.84	48-0.89
25-1.80	25-1.86	49-1.88	49-0.91
FEB. 1-1.79	FEB. 1-1.71	50-1.84	50-0.87
8-1.82	8-1.95	51-1.79	51-0.84
15-1.88	15-2.09	52-1.75	52-0.82
MAPE (%)	MAPE (%)		
3.98	3.94		

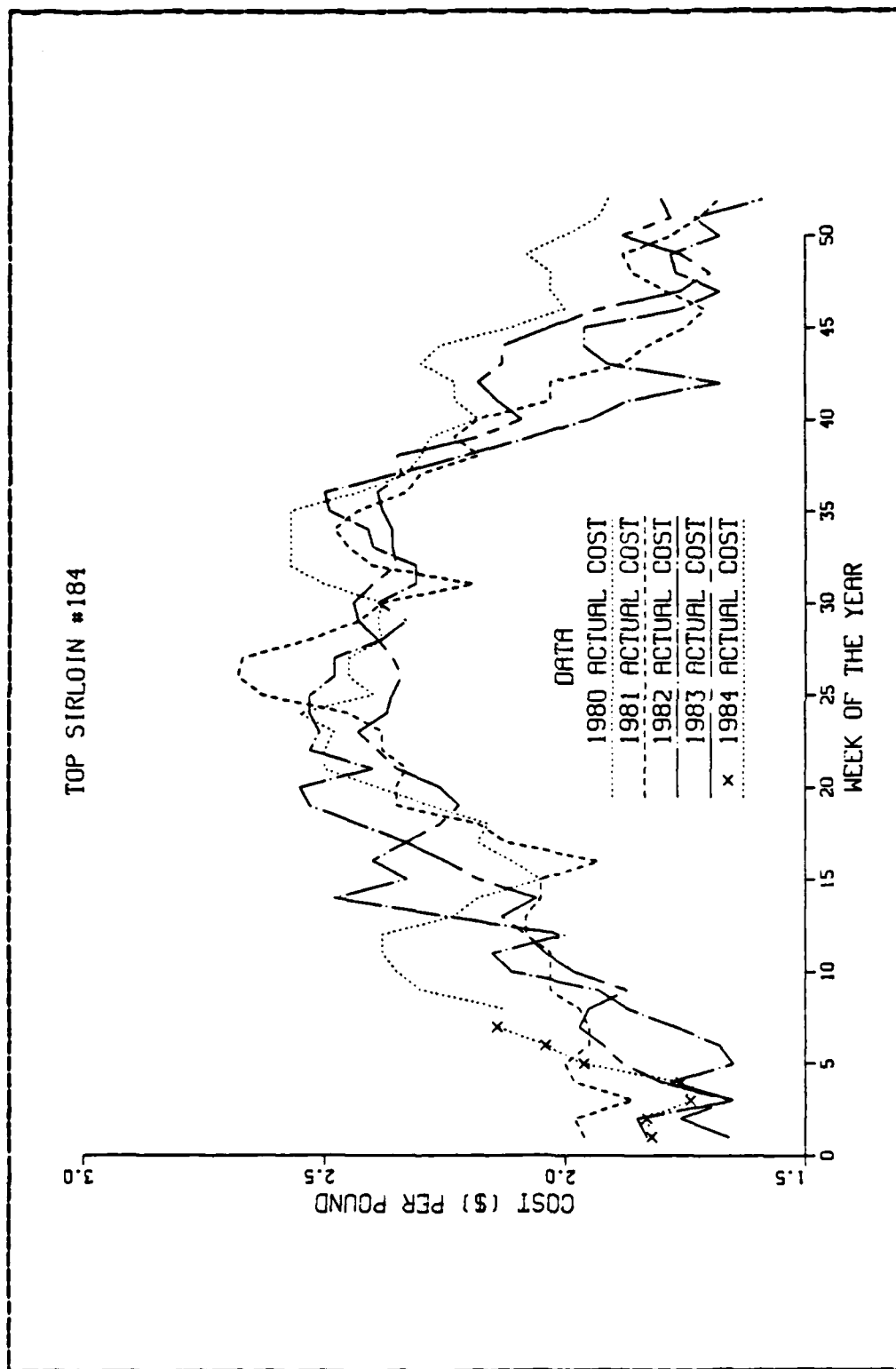


Figure C.1 Cost Data for Top Sirloin (IMPS.184).

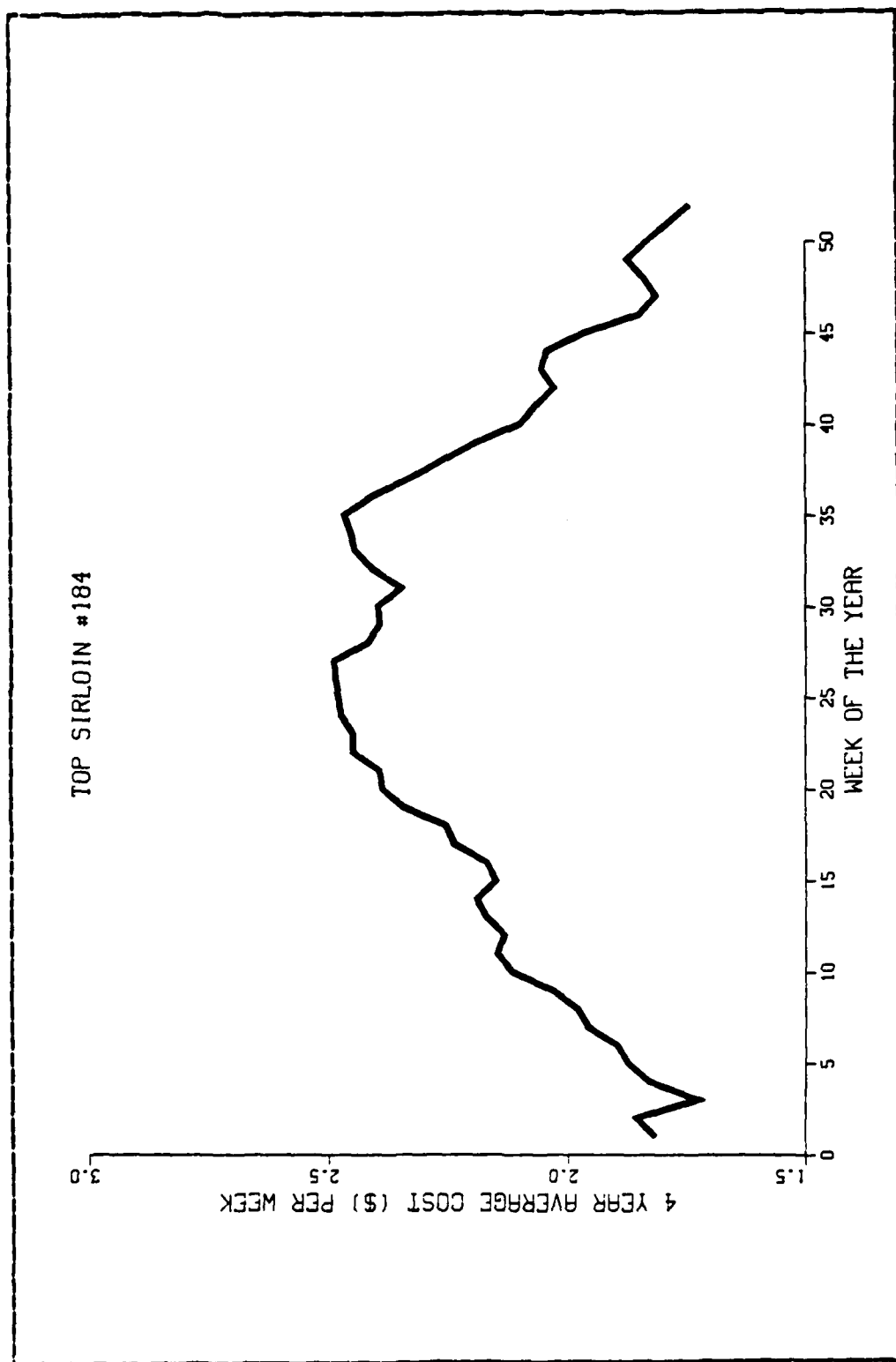


Figure C.2 Average Cost per Week for Top Sirloin (INPS.184).

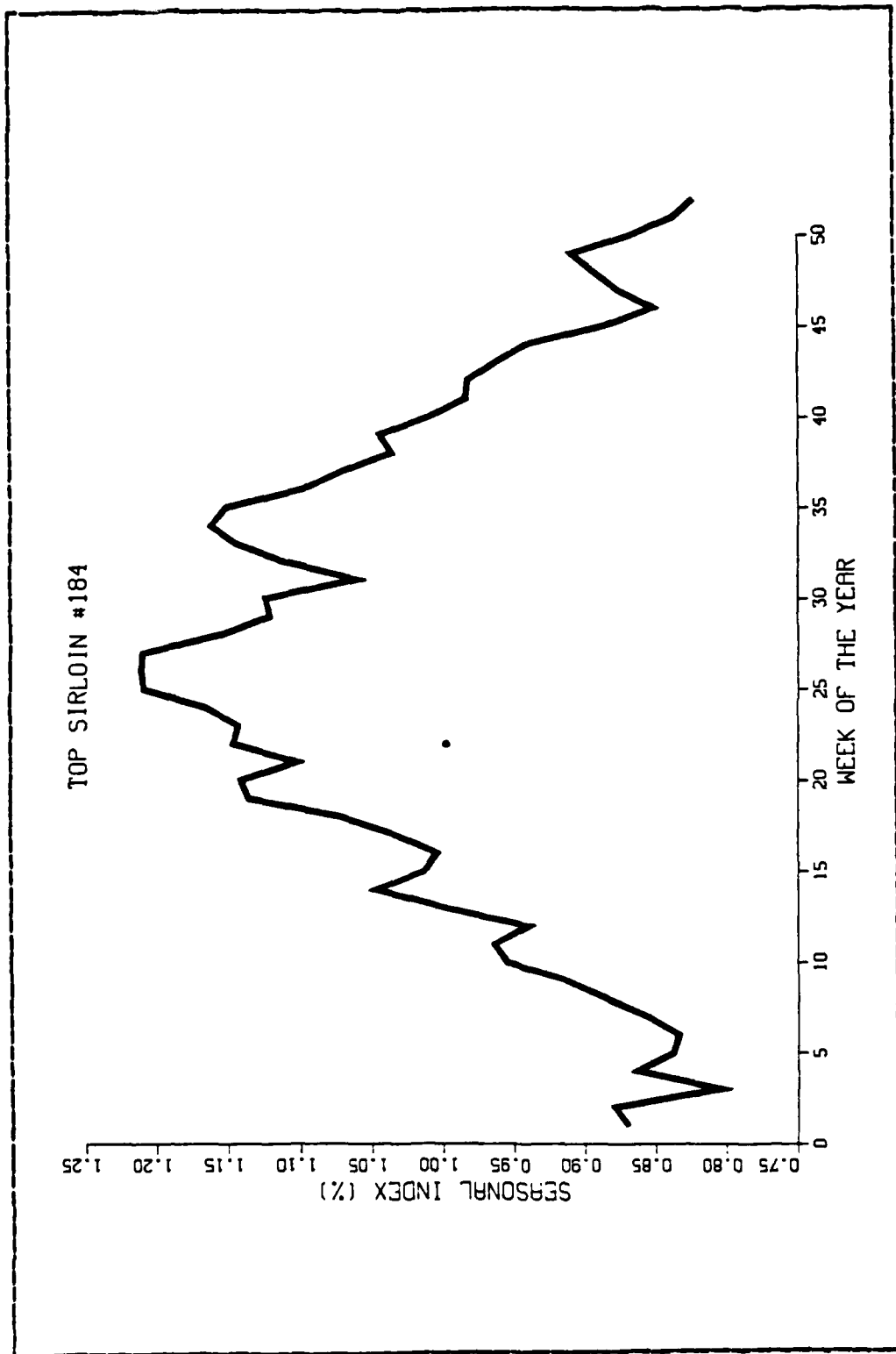


Figure C.3 Seasonal Index for Top Sirloin (IMPS. 184).

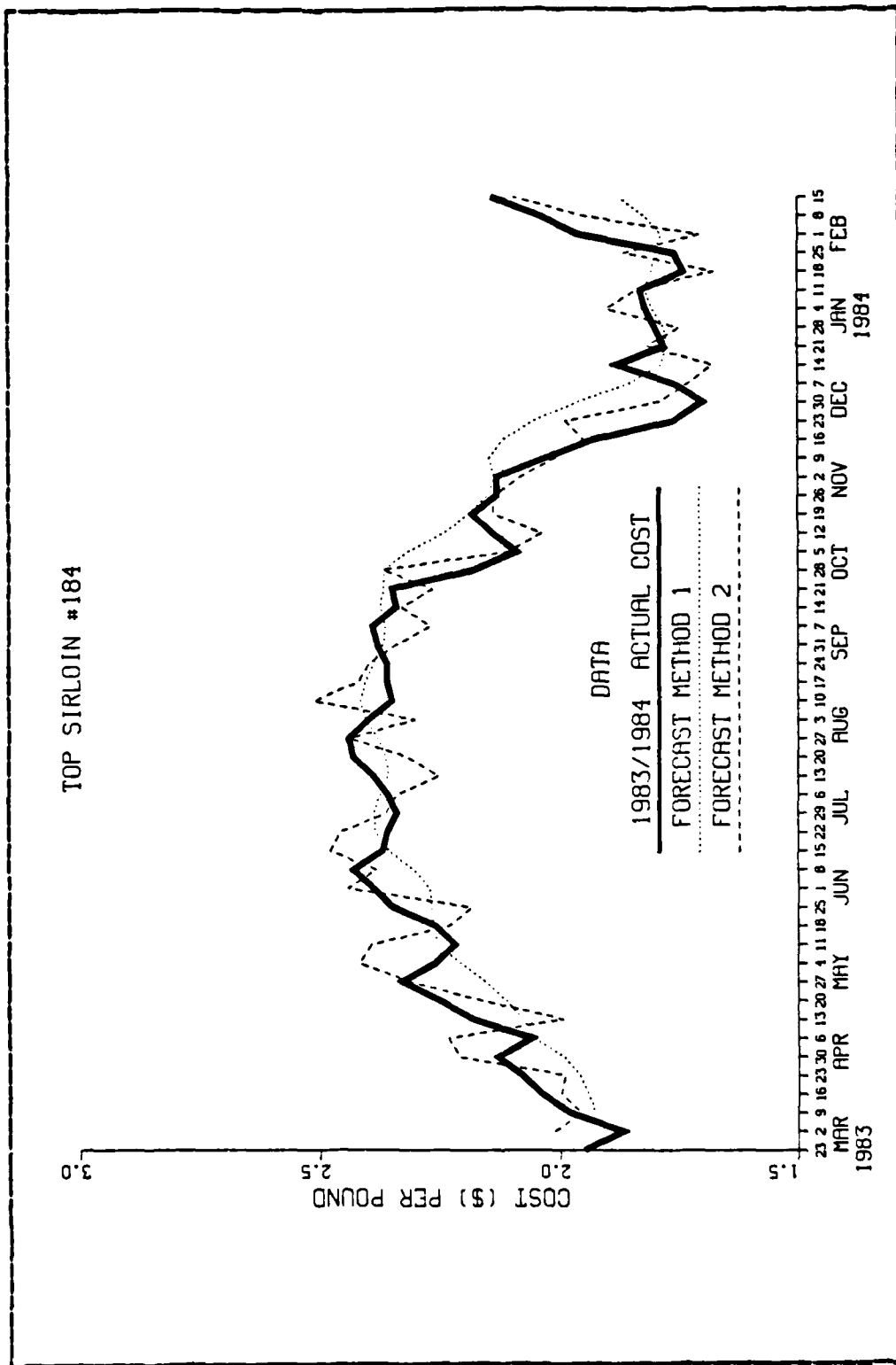


Figure C.4 Comparison of Forecast Methods for Top Sirloin (IMPS.184).

APPENDIX D

TOP (INSIDE) ROUND BEEF (IMPS.168) DATA

TABLE VII
Top (Inside) Round Beef

U.S. Choice Grade, IMPS. Item No. 168
Actual Costs in Dollars per Pound

<u>1980/81</u>	<u>1981/82</u>	<u>1982/83</u>	<u>1983/84</u>
FEB. 27 1.79	FEB. 25 1.70	FEB. 24 1.68	FEB. 23 1.63
MAR. 5 1.73	MAR. 4 1.72	MAR. 3 1.63	MAR. 2 1.58
12 1.73	11 1.60	10 1.70	9 1.67
19 1.75	18 1.58	17 1.63	16 1.64
26 1.70	25 1.60	24 1.64	23 1.58
APR. 2 1.65	APR. 1 1.55	31 1.64	30 1.61
9 1.70	8 1.63	APR. 7 1.85	APR. 6 1.58
16 1.67	15 1.71	14 1.65	13 1.66
23 1.73	22 1.73	21 1.73	20 1.77
30 1.83	29 1.81	28 1.68	27 1.90
MAY 7 1.80	MAY 6 1.80	MAY 5 1.83	MAY 4 1.89
14 1.82	13 1.95	12 1.98	11 1.83
21 1.78	20 1.89	19 1.96	18 1.77
28 1.90	27 1.80	26 2.01	25 1.78
JUNE 4 1.90	JUNE 3 1.93	JUNE 2 2.08	JUNE 1 1.81
11 1.98	10 1.88	9 1.93	8 1.78
18 1.98	17 1.91	16 1.88	15 1.80
25 2.05	24 2.00	23 1.78	22 1.76
JULY 2 2.03	JULY 1 2.03	30 1.78	29 1.72
9 1.98	8 2.00	JULY 7 1.85	JULY 6 1.72
16 1.96	15 1.85	14 1.73	13 1.67
23 2.01	22 1.85	21 1.70	20 1.65
30 1.95	29 1.76	28 1.72	27 1.61
AUG. 6 1.95	AUG. 5 1.76	AUG. 4 1.62	AUG. 3 1.57
13 1.95	12 1.70	11 1.58	10 1.53
20 1.88	19 1.81	18 1.60	17 1.62
27 1.90	26 1.81	25 1.63	24 1.65
SEP. 3 1.90	SEP. 2 1.76	SEP. 1 1.62	31 1.67
10 1.80	9 1.69	8 1.58	SEP. 7 1.64
17 1.83	16 1.68	15 1.55	14 1.55
24 1.73	23 1.71	22 1.56	21 1.55
OCT. 1 1.72	OCT. 30 1.78	29 1.55	28 1.59
8 1.76	7 1.68	26 1.42	25 1.44
15 1.73	14 1.70	13 1.48	12 1.59
22 1.83	21 1.60	20 1.48	19 1.58
29 1.85	28 1.60	27 1.63	26 1.51
NOV. 5 1.80	NOV. 4 1.56	NOV. 3 1.63	NOV. 2 1.46
12 1.73	11 1.56	10 1.51	9 1.46
19 1.67	18 1.58	17 1.54	16 1.40
26 1.68	25 1.67	24 1.62	23 1.53
DEC. 3 1.60	DEC. 2 1.68	DEC. 1 1.67	30 1.53
10 1.73	9 1.68	8 1.50	DEC. 7 1.53
17 1.70	16 1.55	15 1.58	14 1.50
24 1.68	23 1.55	22 1.51	21 1.46
JAN. 1 1.70	JAN. 30 1.57	29 1.48	28 1.64
7 1.70	JAN. 6 1.68	JAN. 5 1.61	JAN. 4 1.68
14 1.80	13 1.58	12 1.65	11 1.76
21 1.71	20 1.58	19 1.57	18 1.71
28 1.83	27 1.78	26 1.68	25 1.66
FEB. 4 1.79	FEB. 3 1.66	FEB. 2 1.58	FEB. 1 1.76
11 1.67	10 1.58	9 1.57	8 1.67
18 1.57	17 1.61	16 1.62	15 1.64

TABLE VIII
Top (Inside) Round Beef (IMPS.168)

Forecast 1		Forecast 2		Avg. Cost		Season Ind.	
	(\$)		(\$)		(\$)		(%)
FEB.	23	FEB.	23	WEEK	1	WEEK	1
MAR.	2	MAR.	2		2		2
	9		9		3		3
	16		16		4		4
	23		23		5		5
	30		30		6		6
APR.	6	APR.	6		7		7
	13		13		8		8
	20		20		9		9
	27		27		10		10
MAY	4	MAY	4		11		11
	11		11		12		12
	18		18		13		13
	25		25		14		14
JUNE	1	JUNE	1		15		15
	8		8		16		16
	15		15		17		17
	22		22		18		18
	29		29		19		19
JULY	6	JULY	6		20		20
	13		13		21		21
	20		20		22		22
	27		27		23		23
AUG.	3	AUG.	3		24		24
	10		10		25		25
	17		17		26		26
	24		24		27		27
	31		31		28		28
SEP.	7	SEP.	7		29		29
	14		14		30		30
	21		21		31		31
	28		28		32		32
OCT.	5	OCT.	5		33		33
	12		12		34		34
	19		19		35		35
	26		26		36		36
NOV.	2	NOV.	2		37		37
	9		9		38		38
	16		16		39		39
	23		23		40		40
	30		30		41		41
DEC.	7	DEC.	7		42		42
	14		14		43		43
	21		21		44		44
	28		28		45		45
JAN.	4	JAN.	4		46		46
	11		11		47		47
	18		18		48		48
	25		25		49		49
FEB.	1	FEB.	1		50		50
	8		8		51		51
	15		15		52		52
MAPE 3.95		MAPE 3.40					

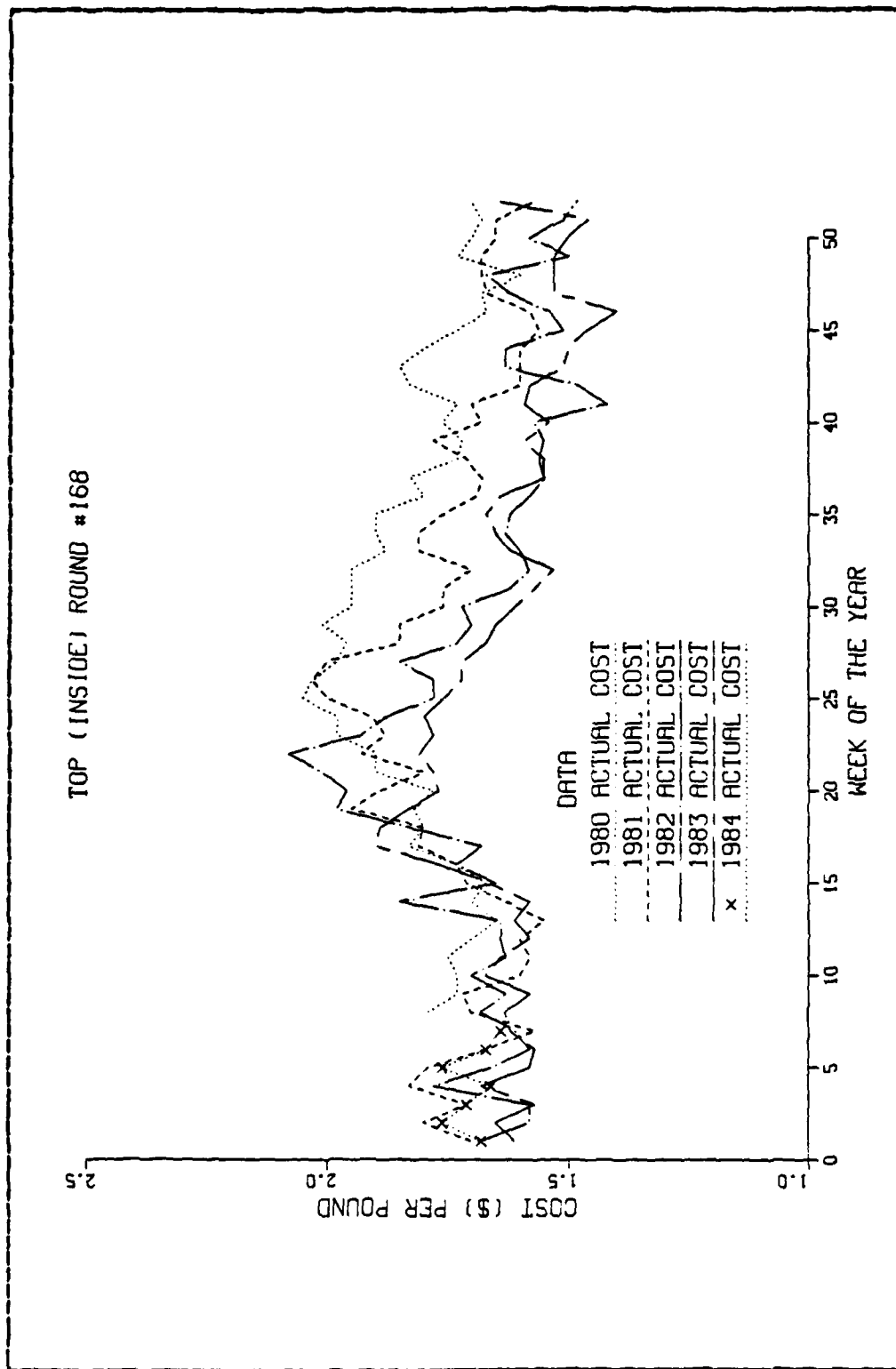


Figure D.1 Cost Data for Top (Inside) Round (INPS.168).

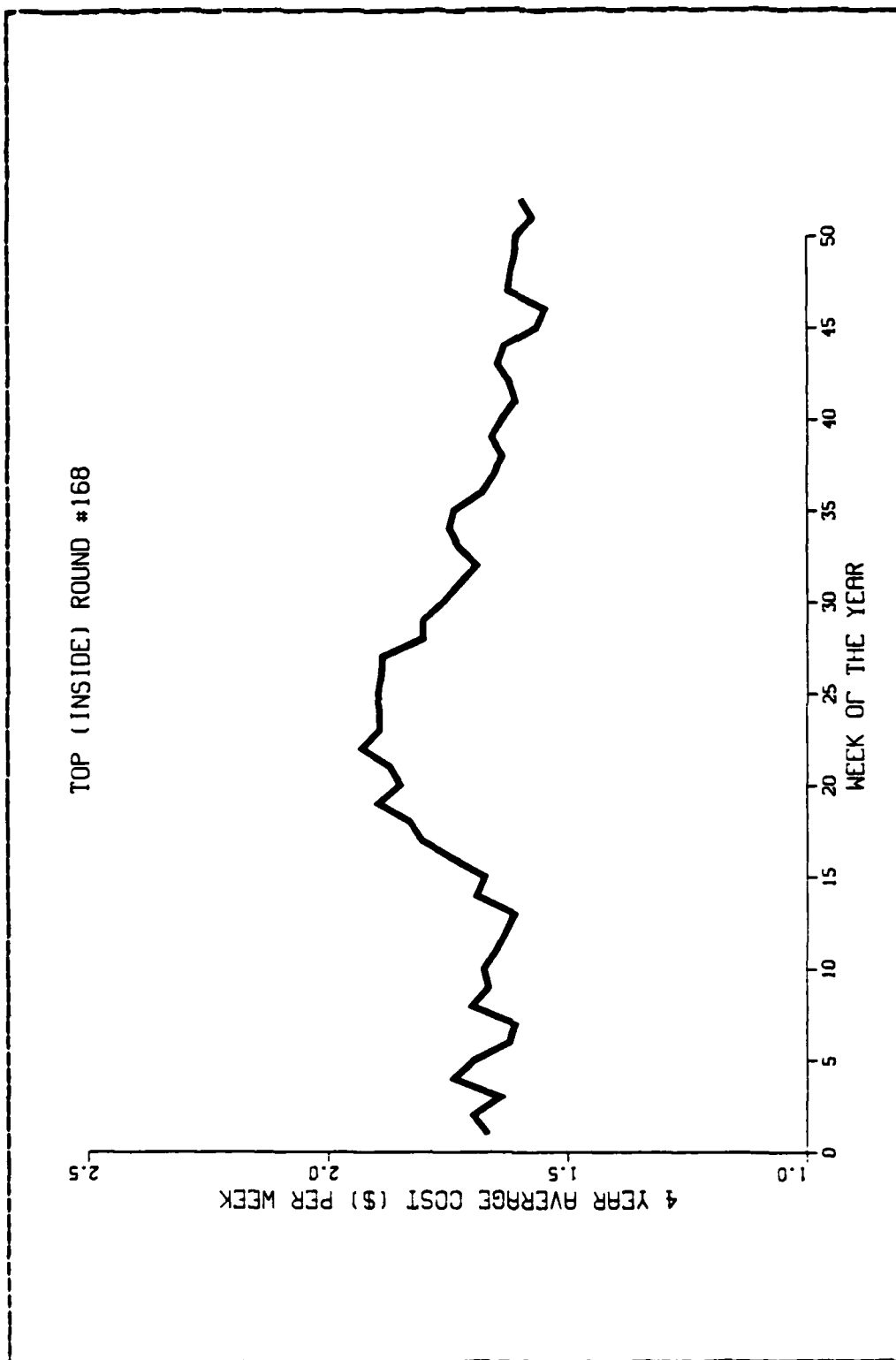


Figure D.2 Average Cost per Week for Top (Inside) Round (IMPS.168).

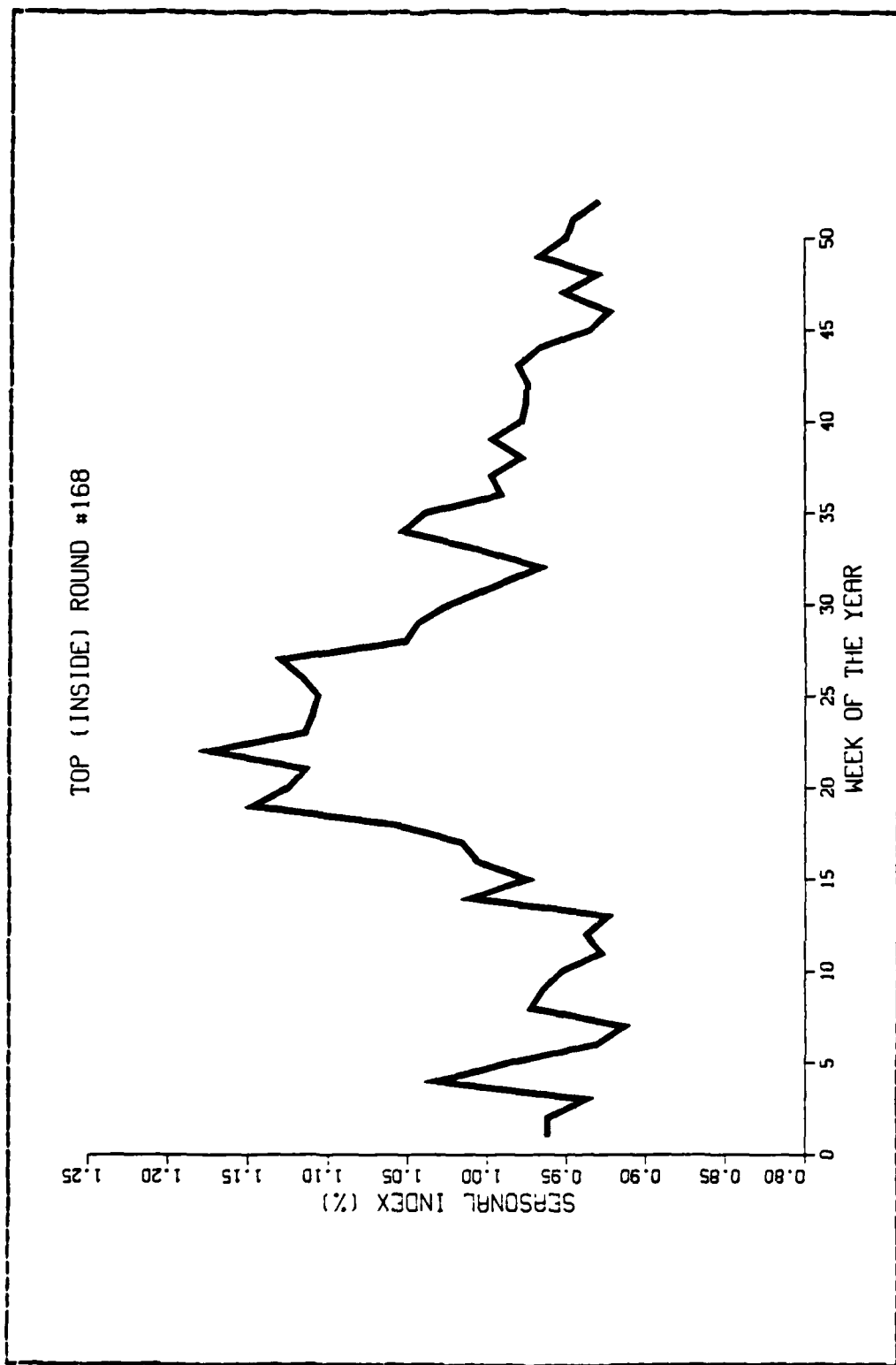


Figure D.3 Seasonal Index for Top (Inside) Round (IHPS.168).

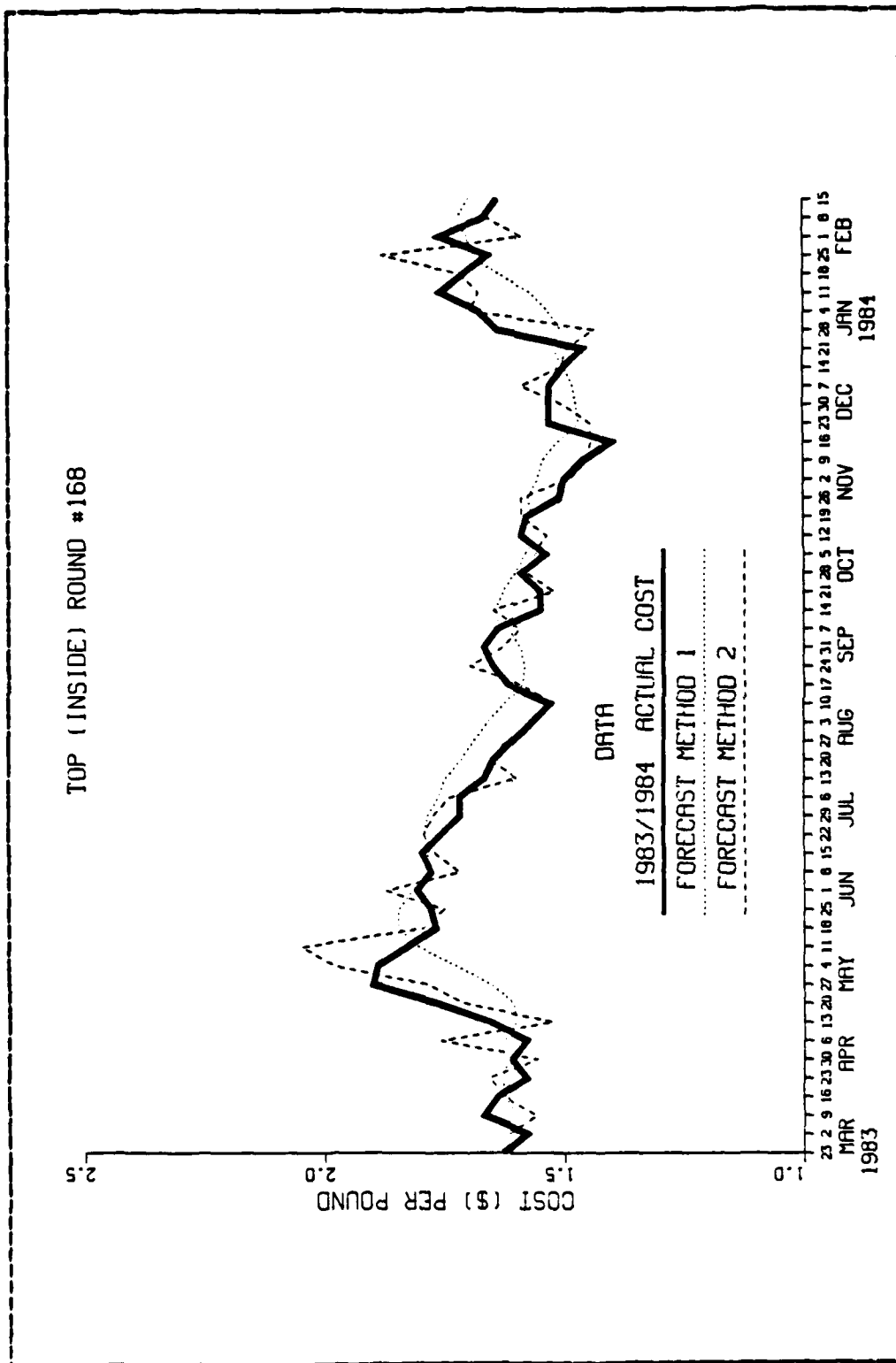


Figure D.4 Comparison of Forecast Methods for Top Round (INPS.168).

APPENDIX E
CHUCK BCLL BEEP (IMPS.116A) DATA

TABLE IX
Chuck Roll Beef

U.S. Choice Grade, IMPS. Item No. 116A
Actual Costs in Dollars per Pound

<u>1980/81</u>	<u>1981/82</u>	<u>1982/83</u>	<u>1983/84</u>
FEB. 27 1.69	FEB. 25 1.63	FEB. 24 1.58	FEB. 23 1.52
MAR. 5 1.58	MAR. 4 1.60	MAR. 3 1.56	MAR. 2 1.47
12 1.58	11 1.50	10 1.56	9 1.52
19 1.59	18 1.46	17 1.50	16 1.48
26 1.58	25 1.46	24 1.45	23 1.39
APR. 2 1.46	APR. 1 1.43	APR. 31 1.51	APR. 30 1.43
9 1.55	8 1.45	APR. 7 1.43	APR. 6 1.41
16 1.45	15 1.48	14 1.48	13 1.45
23 1.49	22 1.41	21 1.50	20 1.51
30 1.53	29 1.50	28 1.50	27 1.50
MAY 7 1.45	MAY 6 1.48	MAY 5 1.51	MAY 4 1.41
14 1.45	13 1.50	12 1.55	11 1.40
21 1.45	20 1.43	19 1.43	18 1.43
28 1.46	27 1.36	26 1.53	25 1.40
JUNE 4 1.36	JUNE 3 1.33	JUNE 2 1.53	JUNE 1 1.37
11 1.44	10 1.38	9 1.41	8 1.36
18 1.57	17 1.38	16 1.43	15 1.35
25 1.53	24 1.31	23 1.40	22 1.44
JULY 2 1.53	JULY 1 1.50	30 1.43	29 1.35
9 1.48	8 1.40	JULY 7 1.43	JULY 6 1.37
16 1.48	15 1.40	14 1.35	13 1.30
23 1.55	22 1.48	21 1.36	20 1.30
30 1.53	29 1.46	28 1.38	27 1.29
AUG. 6 1.53	AUG. 5 1.45	AUG. 4 1.38	AUG. 3 1.24
13 1.53	12 1.47	11 1.38	10 1.24
20 1.53	19 1.51	18 1.46	17 1.28
SEP. 27 1.50	SEP. 26 1.53	SEP. 25 1.46	SEP. 24 1.31
3 1.53	2 1.47	SEP. 1 1.40	31 1.29
10 1.50	9 1.45	8 1.40	SEP. 7 1.28
17 1.48	16 1.51	15 1.45	14 1.29
24 1.48	23 1.56	22 1.35	21 1.29
OCT. 1 1.51	OCT. 30 1.55	29 1.41	28 1.34
8 1.48	29 1.55	26 1.37	25 1.33
15 1.53	28 1.45	23 1.41	22 1.36
22 1.61	27 1.45	20 1.37	19 1.33
29 1.61	26 1.45	27 1.48	26 1.33
NOV. 5 1.51	NOV. 4 1.46	NOV. 3 1.48	NOV. 2 1.32
12 1.53	11 1.41	10 1.43	NOV. 9 1.32
19 1.55	18 1.38	17 1.40	16 1.37
26 1.55	25 1.50	24 1.46	23 1.35
DEC. 3 1.55	DEC. 2 1.51	DEC. 1 1.45	30 1.35
10 1.53	9 1.40	DEC. 8 1.46	DEC. 7 1.36
17 1.50	16 1.43	15 1.51	14 1.43
24 1.50	23 1.33	22 1.41	21 1.33
31 1.51	30 1.35	29 1.39	28 1.40
JAN. 7 1.47	JAN. 6 1.41	JAN. 5 1.39	JAN. 4 1.43
14 1.51	13 1.44	12 1.45	11 1.50
21 1.48	20 1.33	19 1.36	18 1.48
28 1.61	27 1.51	26 1.48	25 1.55
FEB. 11 1.68	FEB. 3 1.60	FEB. 2 1.54	FEB. 1 1.62
18 1.53	17 1.53	16 1.53	15 1.57

TABLE X
Chuck Roll Beef (IMPS.116A)

<u>Forecast 1</u>	<u>Forecast 2</u>	<u>Avg. Cost</u>	<u>Season Ind.</u>
FEB.23 (\$)	FEB.23 (\$)	WEEK 1 (\$)	WEEK 1 (%)
MAR. 2 1.52	MAR. 2 1.50	2 1.48	2 0.96
9 1.53	9 1.43	3 1.41	3 0.94
16 1.51	16 1.47	4 1.53	4 1.05
23 1.50	23 1.46	5 1.61	5 1.10
30 1.46	30 1.41	6 1.57	6 1.04
APR. 6 1.46	APR. 6 1.40	7 1.54	7 1.03
13 1.43	13 1.45	8 1.61	8 1.08
20 1.42	20 1.43	9 1.55	9 1.07
27 1.45	27 1.56	10 1.54	10 1.03
MAY 4 1.47	MAY 4 1.50	11 1.51	11 1.00
11 1.47	11 1.44	12 1.47	12 0.98
18 1.46	18 1.31	13 1.46	13 0.99
25 1.43	25 1.45	14 1.46	14 0.97
JUNE 1 1.41	JUNE 1 1.43	15 1.46	15 1.00
8 1.40	8 1.29	16 1.48	16 0.99
15 1.39	15 1.37	17 1.51	17 1.02
22 1.37	22 1.40	18 1.46	18 1.02
29 1.36	29 1.36	19 1.47	19 1.04
JULY 6 1.35	JULY 6 1.34	20 1.43	20 0.97
13 1.35	13 1.29	21 1.44	21 0.98
20 1.34	20 1.34	22 1.42	22 1.01
27 1.33	27 1.31	23 1.41	23 0.95
AUG. 3 1.32	AUG. 3 1.28	24 1.40	24 0.96
10 1.28	10 1.25	25 1.45	25 0.99
17 1.27	17 1.29	26 1.46	26 1.01
24 1.26	24 1.32	27 1.45	27 1.00
31 1.27	31 1.26	28 1.38	28 0.94
SEP. 7 1.28	SEP. 7 1.27	29 1.42	29 0.97
14 1.29	14 1.34	30 1.42	30 0.97
21 1.30	21 1.33	31 1.40	31 0.97
28 1.29	28 1.30	32 1.41	32 0.98
OCT. 5 1.31	OCT. 5 1.33	33 1.45	33 1.02
12 1.32	12 1.33	34 1.47	34 1.05
19 1.33	19 1.37	35 1.42	35 1.00
26 1.35	26 1.36	36 1.41	36 0.99
NOV. 2 1.34	NOV. 2 1.33	37 1.46	37 1.03
9 1.34	9 1.26	38 1.42	38 1.02
16 1.33	16 1.30	39 1.45	39 1.02
23 1.31	23 1.34	40 1.43	40 1.01
30 1.32	30 1.34	41 1.45	41 1.02
DEC. 7 1.33	DEC. 7 1.32	42 1.45	42 1.02
14 1.33	14 1.36	43 1.47	43 1.02
21 1.37	21 1.38	44 1.47	44 1.03
28 1.38	28 1.41	45 1.42	45 0.98
JAN. 4 1.40	JAN. 4 1.41	46 1.39	46 0.97
11 1.41	11 1.48	47 1.46	47 1.02
18 1.43	18 1.42	48 1.46	48 1.01
25 1.45	25 1.55	49 1.44	49 0.98
FEB. 1 1.48	FEB. 1 1.60	50 1.47	50 0.98
8 1.53	8 1.53	51 1.41	51 0.95
15 1.57	15 1.63	52 1.41	52 0.96
MAPE__ (%)	MAPE__ (%)		
3.00	2.61		

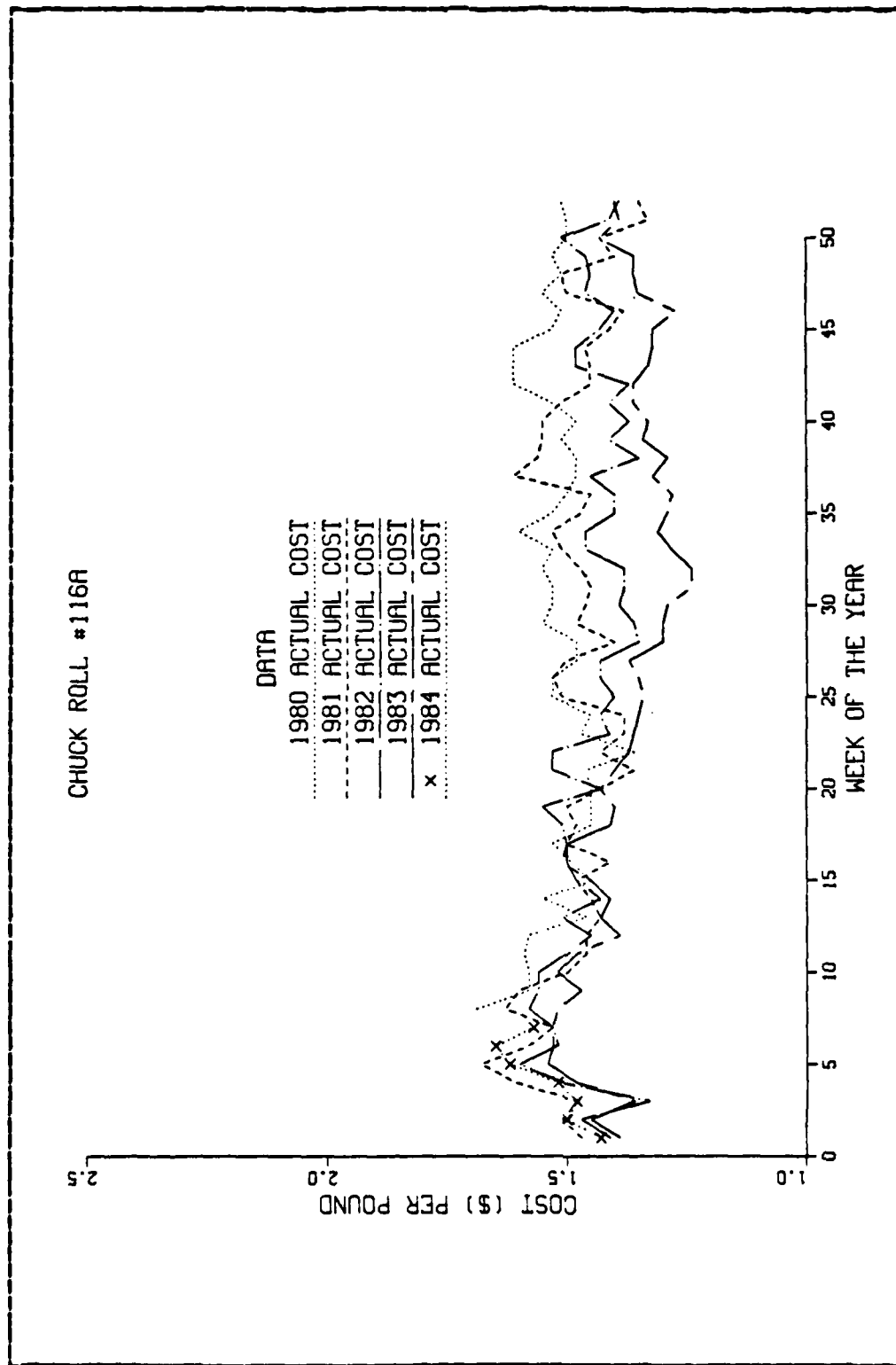


Figure E.1 Cost Data for Chuck Roll (IMPS.116A).

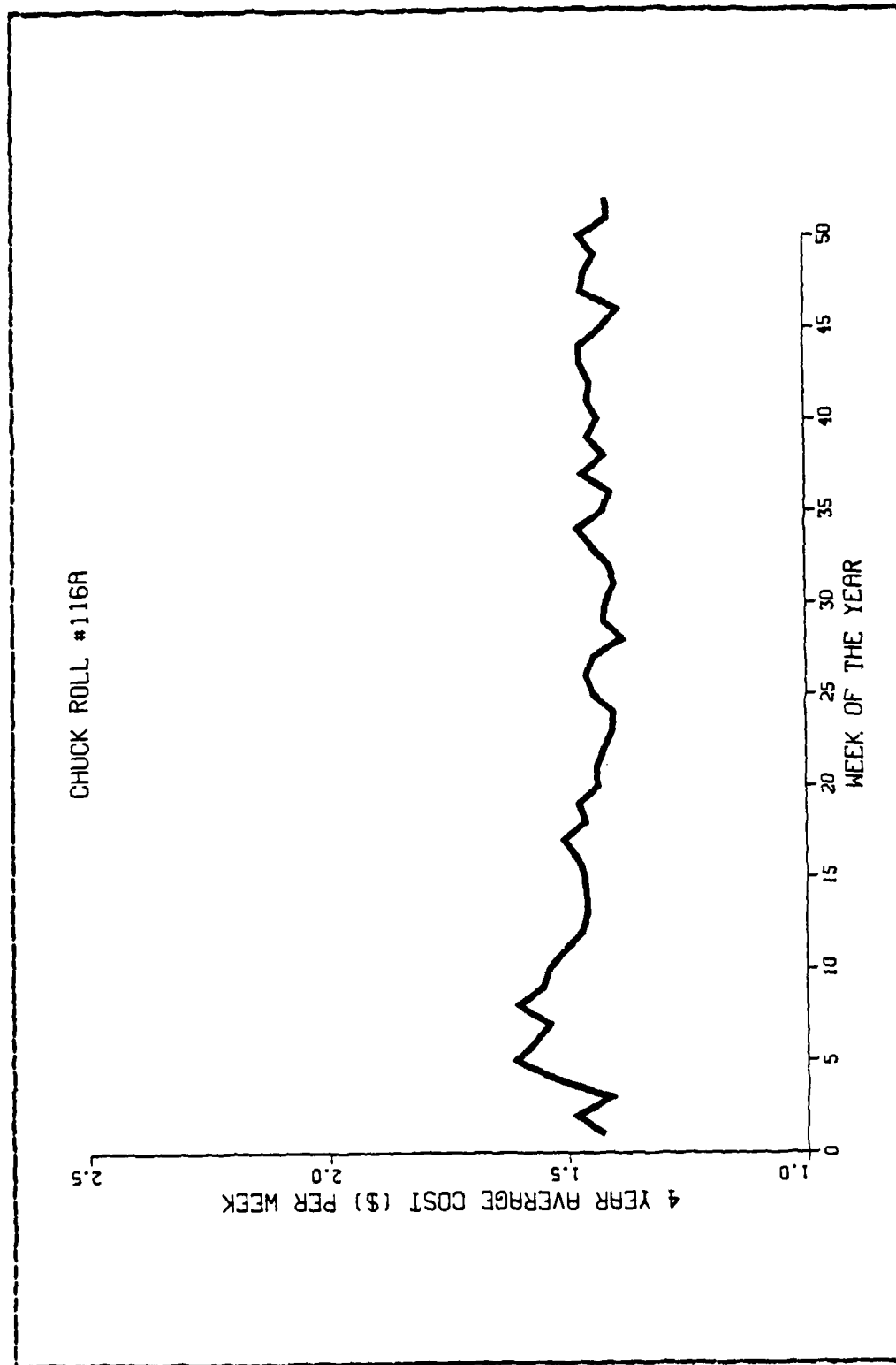


Figure E.2 Average Cost per Week for Chuck Roll (INPS. 116A).

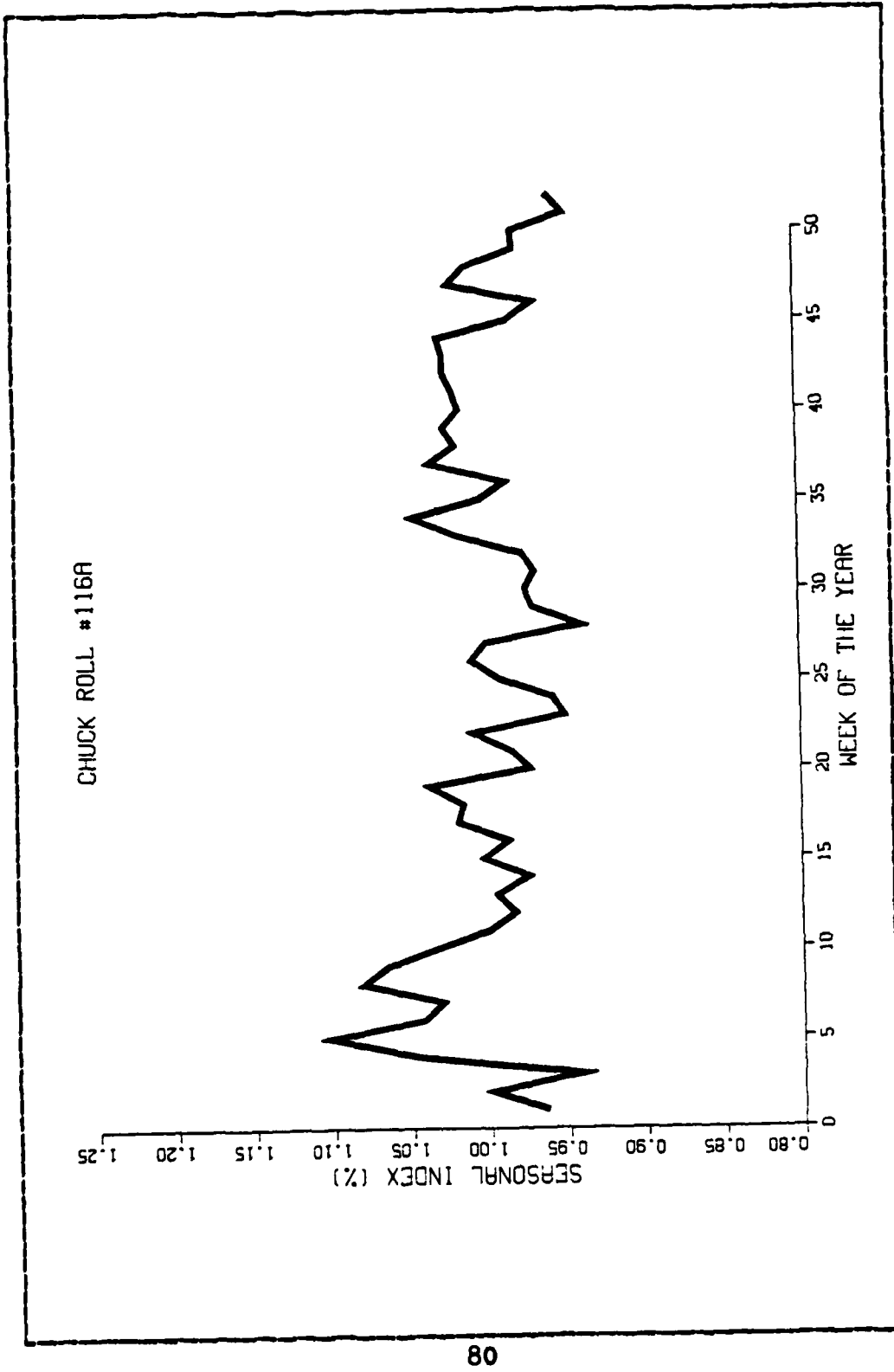


Figure E.3 Seasonal Index for Chuck Roll (IMPS.116A) -

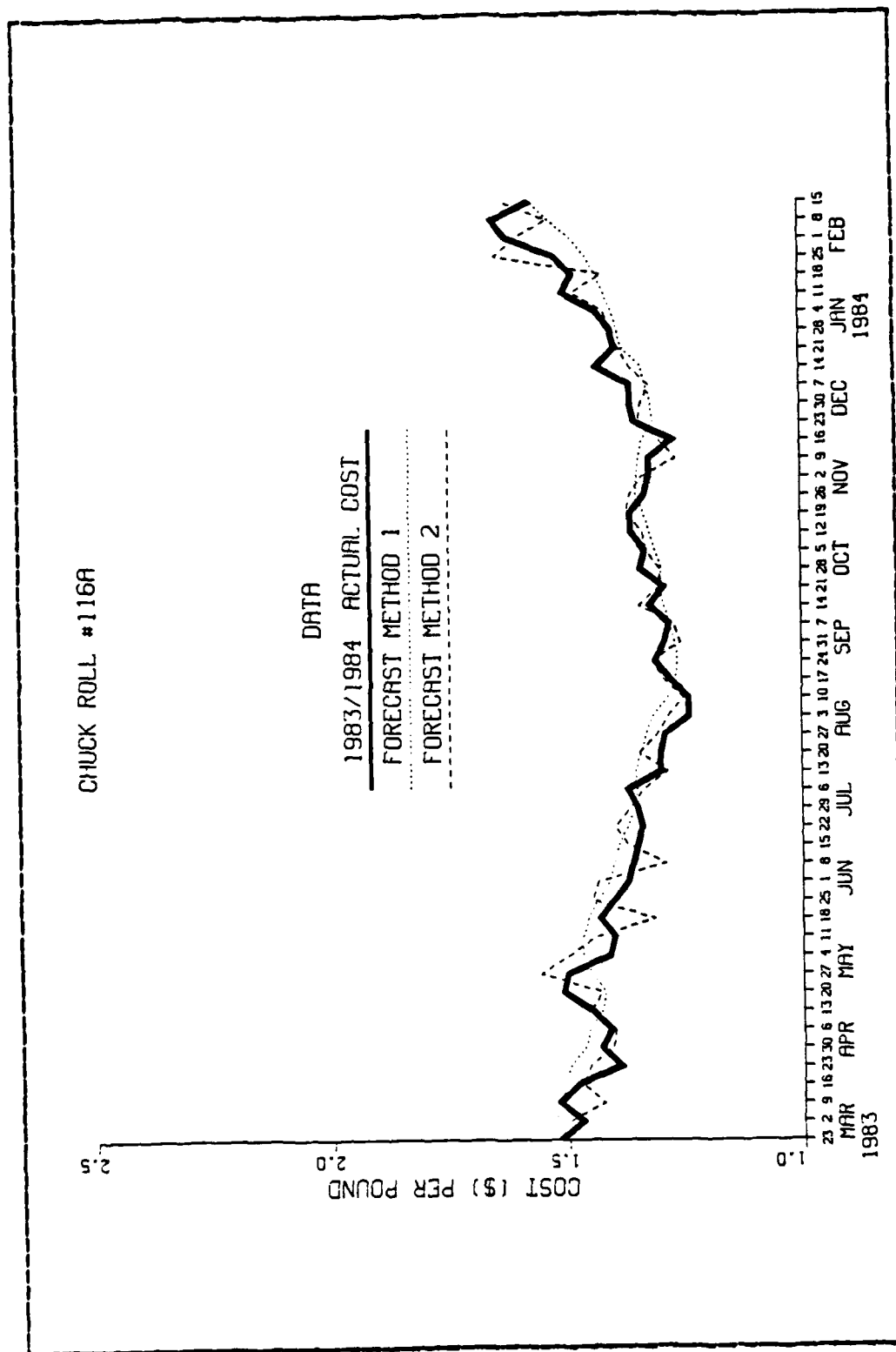


Figure E.4 Comparison of Forecast Methods for Chuck Roll (INPS.116A).

APPENDIX F
PROGRAM TO CALCULATE SEASONAL INDICES

```

$job
c PROGRAM TO CALCULATE SEASONAL INDICES OF TIME SERIES DATA
cc      RATIO-TO-MOVING AVERAGE METHOD
cc
cc      MOVAVG = MOVING AVERAGE
cc      CMOVAVG = CENTERED MOVING AVERAGE
cc      SPECSEA = SPECIFIC SEASONAL
cc      MATRIX = (USED TO DEVELOP ROW AVERAGE TO
cc                  ELIMINATE IRREGULAR COMPONENT)
cc      SEASON = SEASONAL INDEX
cc
      DIMENSION DATA (156),MOVAVG (105),CMOVAVG (104),
1SPECSEA (104),MATRIX(52,4),SEASON (52)
      INTEGER ADD,K,J
      REAL SUM
      DO 10 I=1, 156
      READ (5,25) DATA(I)
25      FORMAT(1X,F9.2)
10      CCNTINUE
c
cc
ccc     CALCULATE 52 WEEK MOVING AVERAGE
cccc
ccccc
      K=1
      ADD=52
      DO 20 I=1, 105
      SUM=0.
      DO 30 J=K, ADD
      SUM=SUM+DATA (J)

```

```

30    CCNTINUE
      MOVAVG(I)=SUM
      ADD=ADD+1
      K=ADD-51
20    CONTINUE
C
CC
CCC   CALCULATE 52 WEEK CENTERED MOVING AVERAGE
CCCC
CCCCC
      K=1
      ADD=2
      DO 40 I=1, 104
        SUM=0.
        DO 50 J=K, ADD
          SUM=SUM+MOVAVG(J)
50    CONTINUE
      CMCVAVG(I)=SUM/104.
      ADD=ADD+1
      K=ADD-1
40    CCNTINUE
C
CC
CCC   CALCULATE SPECIFIC SEASONALS
CCCC
CCCCC
      J=1
      DO 60 I=27, 130
        SPECSEA(J)=DATA(I)/CMOVAVG(J)
        J=J+1
60    CONTINUE
C
CC
CCC   MATRIX (COLUMN 1)
CCCC

```

```

CCCCC
      K=1
      J=1
      DO 70 I=1, 52
      IF (I.IT.34) GO TO 71
      MATRIX(I,J)=SPECSEA(K)
      K=K+1
      GO TO 70
71    MATRIX(I,J)=0
70    CCNTINUE
C
CC
CCC  MATRIX (COLUMN 2)
CCCC
CCCCC
      K=20
      J=2
      DO 80 I=1, 52
      MATRIX(I,J)=SPECSEA(K)
      K=K+1
80    CCNTINUE
C
CC
CCC  MATRIX (COLUMN 3)
CCCC
CCCCC
      K=72
      J=3
      DO 90 I=1, 52
      IF (I.GT.33) GO TO 91
      MATRIX(I,J)=SPECSEA(K)
      K=K+1
      GO TO 90
91    MATRIX(I,J)=0
90    CCNTINUE

```

```

C
CC
CCC  CALCULATE SEASONAL INDICES
CCCC (ROW AVERAGE OF MATRIX)
CCCCC
      SUM=0.
      DO 200 I=1, 52
      DO 300 J=1, 3
      SUM=SUM+MATRIX(I,J)
300  CCNTINUE
      SEASON(I)=SUM/2.
      SUM=0.
200  CCNTINUE
C
CC
CCC  PRINT SEASON INDICES
CCCC
CCCCC
      DO 220 I=1, 52
      WRITE(1,250) SEASON(I)
250  FORMAT(1X,F9.5)
220  CCNTINUE
      STCP
      END
$ENTRY

```


APPENDIX G
PROGRAM TO CALCULATE FORECAST METHOD 2

```
$JOB
C   PROGRAM TO CALCULATE FORECAST METHOD 2
CC
    DIMENSION DATA (52),SIFD (52),SITD (52),FORECAS (52)
    INTEGER K
    REAL SITD
    DO 10 I=1, 52
    READ (5,15) DATA (I),SIFD (I),SITD (I)
15  FCBMAT (1X,F7.5,1X,F8.6,1X,F8.6)
10  CONTINUE
C
CC  FORECAST CALCUIATIONS
CCC
    K=2
    TCH (1)=0
    DO 20 I=1, 51
    FORECAS (K) = (SIFD (K)/SITD (I)) *DATA (I)
    K=K+1
20  CONTINUE
C
CC  PRINT FORECAST RESULTS
CCC
    DO 30 I=1, 52
    WRITE (1,45) FORECAS (I)
45  FCBMAT (1X,F7.5)
30  CONTINUE
    STOP
    END
$ENTRY
```

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